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**EUROPEAN SCIENTIFIC NOTES  
OFFICE OF NAVAL RESEARCH  
LONDON**

Edited by T.C. Cheston and Don J. Peters

31 January 1981

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*W. J. CondeLL*

W.J. CONDELL  
Chief Scientist

*P. F. Gibber*

P.F. GIBBER  
Captain, USN  
Commanding Officer

CDR R.F. Ashford  
Dr. W.V. Burt  
Mr. T.C. Cheston  
Dr. P. Fire

Dr. M.A. Greenfield

CDR J.A. Holt  
Dr. R.E. Machol

Dr. J.R. Neighbours  
Dr. A.P. Schaap  
CDR C.H. Spikes

CDR J.A. Strada  
Mr. Y.S. Wu

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## CHEMISTRY

### ION FORMATION FROM ORGANIC SOLIDS

The first International workshop on "Ion Formation From Organic Solids" was held at the Physical Institute of the University of Münster on 6-8 October 1980. The workshop was organized by Prof. A. Benninghoven (Univ. of Münster), and Sponsored by the German Research Society (Deutsche Forschungsgemeinschaft) and the US Office of Naval Research.

The purpose of the workshop was to examine experimental and theoretical questions concerning the formation of ions from organic solids; the primary goal was to explore the similarities between several new ionization methods that have been used in recent years for the study of nonvolatile organic solids. These methods include field desorption (FD), Californium-252 plasma desorption (PD), laser desorption (LD) and secondary ion mass spectrometry (SIMS). Although each method employs a very different excitation process, the resulting ion spectra are remarkably similar. For example, thermally labile molecules not only survive the energetic excitation process but appear as protonated, cationized, or deprotonated molecular-like ions, similarities of which suggest related ionization processes. An understanding of the mechanisms of ion formation is required in order to successfully interpret ion spectra of organic compounds. Several of these new methods have been used to identify various types of compounds such as amino acids, peptides, nucleotides, pharmaceutical products, drugs, and vitamins. These techniques also have demonstrated detection limits below  $10^{-12}$  g and a mass range capability of  $>1000$  amu.

In addition to the primary goal, the workshop had the following important objectives:

- (1) To establish a dialog between the active groups in these fields.
- (2) To discuss the various models proposed for the different ion formation processes.
- (3) To suggest and coordinate new experiments.
- (4) To discuss those factors that influence the ion formation process, e.g., sample preparation.
- (5) To define the current technical limitations of the experimental arrangements.
- (6) To explore potential applications of these techniques in such fields as organic trace analysis, surface chemistry, biochemistry, medicine, and forensic chemistry.

Thirty-seven scientists from nine countries participated in the workshop. This is how these countries were represented: Austria, 1; Belgium, 1; Canada, 1; Denmark, 1; FRG 20; the Netherlands, 2; Sweden, 2; the UK 1; and the US 8. A brief summary of the program is outlined below; the proceedings of the workshop are to be published by Springer-Verlag in early 1981.

The first day's program was largely tutorial in nature, consisting of presentations on field desorption,  $^{252}\text{Cf}$  plasma desorption, laser desorption, and SIMS. The authors were asked to comment individually on (1) the number and type of ions produced by a given method (2) the ion yield and energy distribution, (3) the current understanding of the excitation process, and (4) the effects of sample preparation on their respective techniques. Supplementary talks covering certain aspects of each method followed the principal address. The remainder of the workshop was devoted to open discussions and other more specialized topics such as ion formation mechanisms, analytical applications, and instrumentation.

Prof. F.W. Röllgen (Univ. of Bonn) presented the tutorial on field desorption mass spectrometry (FDMS). FDMS was the first technique to revolutionize the study of nonvolatile and thermally labile compounds. Although the mass spectrum is typically characterized by intense  $(\text{M}+\text{H})^+$  or  $(\text{M} + \text{alkali})^+$  ions,  $\text{M}^+$  molecular ions have been observed for more volatile molecules. The fragmentation pattern is limited and known to vary with emitter preparation (type, loading, and solvent) and temperature. For example, long needle emitters produce extensive sucrose fragmentation while shorter needles permit lesser fragmentation. The direct emission of cations, e.g.,  $\text{N}(\text{CH}_3)_4^+$  from  $\text{N}(\text{CH}_3)_4\text{I}$ , has been observed. Negative ion FD spectra of some inorganic salts, vitamins, sulfonic acids, and saccharides have also been reported. Röllgen also discussed three ionization mechanisms involving field ionization, dissolution of ions from condensed layers, and thermionic processes.

Prof. R.D. Macfarlane (Texas A&M Univ.) discussed plasma desorption mass spectrometry (PDMS) in which MeV particles from the fission of  $^{235}\text{Cf}$  are the source of excitation. Sample molecules are deposited from solution onto a thin Ni foil and subsequently desorbed as ions as the fission fragments (a typical pair being  $79 \text{ MeV } ^{141}\text{Cs}^{+20}$  and  $104 \text{ MeV } ^{146}\text{Tc}^{+20}$ ) pass through the metal foil. The ions are collected by a time-of-flight (TOF) mass spectrometer and in many cases both

molecular-like ions  $(M+1)^+$  and  $(M-1)^-$  are present in the spectra. Moreover, alkali-ion attachment can often be observed and, less frequently, halogen attachment. ( $M^{\pm}$  molecular ions have also been observed for colored molecules.) Although the fragmentation is limited, it is still greater than in FD spectra. Some PD spectra of biomolecules were presented; in particular, some polynucleotides with mass  $\sim 12,000$  amu have been observed. Prof. K. Wien (Technische Hochschule Darmstadt, FRG), Dr. B. Sundquist (Univ. of Uppsala) and Dipl. Phys. P. Dück (Univ. of Erlangen, FRG) presented supplementary information on MeV techniques dealing with ion desorption mechanisms determined by measuring ion yield and energy distributions as a function of incident angle, beam energies, and stopping powers. Wien presented some high-energy sputtering results from clean metal foils using  $^{252}\text{Cf}$  PDMS. He found that the yields of metal ions were in agreement with Sigmund's collisional sputter theory. Dück discussed the desorption of organic compounds from solid surfaces by bombardment with  $^{16}\text{O}$ ,  $^{19}\text{F}$ , and  $^{32}\text{S}$  ion beams (with energies between 8 and 40 MeV) from a tandem accelerator. He concluded that these ions, although considerably lower in mass and energy, produced mass spectra similar to those obtained using  $^{252}\text{Cf}$  fission products. He measured the relative ion yields and energy distributions of ions desorbed from an amino acid as a function of the incident energy of the primary ions. The secondary ion yield increased with increasing energy loss in the sample surface.

Benninghoven presented the tutorial on SIMS. Secondary ions are sputtered during the impact of low energy (a few keV) primary ions. In addition to protonated molecular ions, cationization of M occurs via attachment of either metal ions from the substrate or metal salts or alkali ions from alkali salts. Benninghoven stressed the importance (and influence) of surface preparation on secondary ion yields. While amino acids deposited from aqueous solution gave high background and contaminant peaks, those acids deposited by evaporation yielded clean spectra. He also showed that a 9 keV  $\text{Cs}^+$  ion beam resulted in less fragmentation for amino acids than a 1 keV beam. Supplementary SIMS talks were given by Dr. R.J. Colton (NRL) and Prof. R.G. Cooks (Purdue Univ.). Colton discussed the fragmentation patterns of several amino acids and the factors such as surface coverage and surface roughness which influence ion emission. When the adsorbed amino acid film is too thick,

the positive molecular ion emissions drop considerably, an observation which indicates the need for close proximity between the metal substrate and the amino acid molecule. He also correlated other molecular SIMS data with inter-atomic/molecular binding forces and found that (1) covalently bonded molecules within a molecular lattice seem to eject intact and undergo ion-molecule reactions and (2) covalently bonded anions within an ionic lattice seem to eject intact and dissociate in the gas phase. Cooks outlined the various ionization processes found in organic SIMS: direct ejection, heterolysis, cationization/anionization, and electron transfer. The direct ejection mechanism produced the most intense yield, allowing the detection of picogram quantities of some organic cations. Organic dications were also observed. Cooks' group avoided the problems and inconsistencies associated with surface preparation by using ground powders (organic plus transition metal salt) for samples. Cooks also described ionization experiments using a  $\text{NH}_4\text{Cl}$  matrix which tends to eliminate all but the true fragmentation peaks.

Prof. F. Hillenkamp (Univ. of Frankfurt) described the experimental arrangements for laser desorption mass spectrometry (LDMS). Ionization occurs mostly by attachment of an alkali cation to the desorbed molecules. The alkali species are usually present only as surface contaminants. Doz. Dr. E.R. Schmid (Univ. of Vienna) discussed the application of LD and chromatography. Dr. P.G. Kistemaker (FOM-Inst. for Atomic and Molecular Physics, Amsterdam) discussed the intensity variation in the cationization process with different laser wavelengths and laser powers. He obtained a ratio  $>1$  for  $(M+\text{Na})^+ : (M+\text{K})^+$ ,  $M = \text{sucrose}$ , with a  $\text{CO}_2$  laser at  $10.6 \mu\text{m}$  but a ratio  $<1$  with a Nd laser at  $1.06 \mu\text{m}$ . Some of his experiments were conducted on the tip of a thermocouple from which he drew some correlation between bulk sample temperature and ion emission.

The second day of the workshop began with talks on "Other Ionization Processes" such as thermal desorption and field and electron ionization. Prof. J. Block (Fritz-Haber Institute, Berlin) spoke on laser-assisted field desorption. He observed a linear correlation of the number of photons-in to the number of ions-out. Dr. A. McCormick (Aldermaston-UK) spoke of in-beam EI and CI techniques. Prof. J. Drowart (Univ. of Brussels) used thermal evaporation followed by LI to address the question, "When do we get parent fragment ions?" He used the Frank-Condon principle to predict

bound or dissociated products. Dr. R. Stoll discussed models for thermal desorption from organic solids and the absence of fragmentation in this process.

The next session was devoted to areas of analytical applications. Prof. H.R. Schulten (Univ. of Bonn) and Dr. J.J. Veith (Univ. of Darmstadt) discussed FD applications. Dr. H.J. Heinen (Leybold-Heraeus, Cologne) and Prof. D. Hercules (Univ. of Pittsburgh) discussed applications with the LAMMA (Laser Microprobe Mass Analyzer) instrument. Hercules compared LDMS and SIMS results for some polymers. The positive SIMS and LAMMA spectra were essentially identical and yielded information about the appendages of several acrylic polymers. Dr. W. Sichtermann (Univ. of Münster) spoke on organic SIMS of amino acids and a newly constructed LC-SIMS instrument. The LC-SIMS instrument uses a revolving metal band onto which the effluent of the LC is deposited and analyzed by SIMS. Dr. H. Jungclas (Philipps Univ., Marburg, FRG) spoke on LC-PDMS. The discussion session which followed tried to determine the current standing and the use of these techniques to address real-world problems such as the analysis of complex mixtures. It was agreed that LC-MS techniques were good first steps towards mixture analysis. Other discussion centered around aspects of quantitative calibration for which a "Round Robin" test was suggested but ultimately ruled out.

The afternoon session began with a comparison of spectra, yields, and sample preparation. Prof. K.G. Standing (Manitoba Univ.) obtained some remarkably similar SIMS and  $^{252}\text{Cf}$  PDMS data for some organics with TOF instruments. The PD technique was shown to produce slightly more fragmentation. Dr. F.R. Krueger (Univ. of Frankfurt) compared the ion emission processes of PD and LD. He specified two modes of emission for LD: desorption ( $10^7 - 10^8 \text{ W/cm}^2$ ) and evaporation ( $10^9 - 10^{10} \text{ W/cm}^2$ ). The former mode shows more surface sensitivity. The PD results are comparable to the desorption mode.

The final session of the day dealt with the ion formation processes. Prof. P. Sigmund (Odense Univ., Denmark) began with an overview of the collision processes in sputtering. He outlined a  $2 \times 2$  matrix depicting elastic (nuclear) vs inelastic (electronic) events for linear (rigid lattice) and nonlinear (nonrigid lattice) cases. The differentiation between linear and nonlinear cases is dependent on the density of energy input per unit volume. Krueger then outlined a thermal mechanism for PD and LD which lies between pure electron plasma and thermal evapora-

tion processes. PDMS is believed to be more electron plasma-like while LDMS is more thermal evaporation-like. On the following day Dr. N. Fürstenau (Univ. of Frankfurt) showed experimental dependency of molecular ion emission on bulk sample temperature during desorption. He also presented some quantitative results for equilibrium and non-equilibrium evaporation processes. Prof. F. Field (Rockefeller Univ.) discussed the chemistry of fragmentation and ion-molecule reactions in PDMS. An open discussion on ion formation was led by Sigmund in which a thermal desorption mechanism for PD, LD, and FD was considered. The mechanism for SIMS, on the other hand, is predicted to differ since collisional sputtering effects cannot be ignored.

The final presentation dealt with instrumentation. Prof. H. Wollnik (Philipps Univ., Marburg) gave some introductory remarks concerning double focusing and TOF instruments. Colton described a new high mass performance SIMS instrument (double focusing type) capable of high mass analysis ( $>5000 \text{ amu}$ ). Macfarlane detailed the calibration procedure of the TOF instrument employed in PDMS studies.

The final discussion dealt again with the ion formation process, i.e., desorption-ionization. Concepts of a nonequilibrium thermal mechanism were discussed. The energy transfer mechanism in FD, PD, and LD were attributed to electron excitation while atoms play the important role in SIMS excitation. Cooks presented an excellent summary in which he depicted three desorption-ionization events. The first event deals with "vibrational desorption" in which the weakest intermolecular bonds are broken giving  $\text{M}\dot{\text{O}}$ ,  $\text{C}\dot{\text{O}}$  (cation), and  $\text{A}\dot{\text{O}}$  (anion). The second case deals with "electron ionization" to form  $\text{C}^+$  and  $\text{A}^+$  ions. The third event involves simple associative and dissociative reactions seen as protonation, deprotonation and cationization.

In conclusion, I attribute the success of this first international workshop on "Ion Formation From Organic Solids" to the wide interdisciplinary background of the participants which helped to stimulate active discussion. A second workshop was proposed prior to the Triennial Mass Spectrometry Conference to be held in Vienna in August 1982. By then, many of the topics discussed will be more fully developed. (Richard J. Colton, Naval Research Laboratory)

LIQUID CRYSTAL POLYMERS SYMPOSIUM

Held at the University of Leeds on 16, 17 July 1980, this conference was the first scientific symposium to be conducted under the sponsorship of the newly-formed "Pure and Applied Macromolecular Chemistry Group" (Macro Group UK) of the combined organizations of the Chemical Society and the Society of the Chemical Industry. The conference program was organized by Dr. John Rose of the ICI (Imperial Chemical Industries) Plastics Division and consisted of 15 invited papers on both thermotropic (in the melt) and lyotropic (in solution) liquid crystal polymers.

This subject is now receiving considerable industrial interest and activity because of the outstanding mechanical properties of duPont's "Kevlar" fiber, which is spun from a lyotropic solution of an aromatic polyamide and owes its unusually high tensile properties to the high degree of molecular orientation achievable in such a process. There is also considerable interest in possible applications of such polymers to molded plastics (by melt processing of thermotropic polymers) and in display applications to replace low-molecular-weight, liquid-crystal compounds. In any case, liquid-crystal polymers represent a new state of matter, and for this reason alone, the conference was well justified.

Two-thirds of the papers were concerned with thermotropic polymers, primarily with aromatic polyesters. Dr. R.W. Lenz (Univ. of Massachusetts, Amherst) discussed the project in progress in his laboratory sponsored by ONR on the effect of rigid and flexible "spacer groups" separating the liquid crystal forming mesogenic units on the thermal properties of aromatic polyesters containing such groups. The mesogenic groups were either *p*-oxybenzoate or hydroquinone terephthalate units. The temperature ranges over which these polymers showed nematic behavior, and the enthalpies and entropies of transition were the principal variables studied. The polymers were characterized by hot-stage microscopy on a polarizing microscope for melt birefringence and stir opalescence, by DCS for thermal properties, and by x-ray and small-angle light-scattering methods for nematic and crystalline structure and morphology.

Dr. B.P. Griffin (ICI Plastics Div.) also described the effect of non-mesogenic units on the liquid crystalline properties of aromatic copolyesters. He presented phase diagrams for several such systems relating thermal properties to copolymer compositions covering the crystalline or glassy solid state, the nematic melt state, and the isotropic melt state.

A principal goal of this work was to reduce the melt transition temperature for formation of the nematic state either by copolymerizing non-mesogenic units to reduce crystallinity, by using flexible mesogenic units, or by using laterally-substituted mesogenic units. Of particular interest was his observation of the existence of stable biphasic regions containing both nematic and isotropic phases.

Dr. J. Jackson, Jr., (Tennessee Eastman Co., Kingsport) reviewed the history of investigations of thermotropic polyesters and discussed the effect of polymer structure on mechanical and crystalline polymers in such materials. He described the important variables for achieving superior mechanical properties in injection molding of these polymers. He also emphasized the importance of non-aromatic, flexible "spacers" in reducing the melting points of liquid crystal polyesters, as did the fourth speaker in this series of papers on the nematic state properties of aromatic polyesters, Dr. J.E. McIntyre (Univ. of Leeds). His investigations also included the properties of thermotropic polymers based on aromatic poly (ester amides).

All of the polymers referred to above showed only nematic behavior in the melt, but Dr. C. Noel (CNRS, Paris) described aromatic polyesters that formed smectic phases. She also studied the orientation of liquid crystal polyesters by magnetic fields and observed that the polymers behaved essentially in the same manner as low molecular weight compounds in that respect. Dr. K. Wissbrun (Celanese Research Co.) described his work on the melt flow properties of thermotropic polyesters in the liquid crystalline state. Under such conditions their rheological properties were much different from those of polymers with isotropic melts in that they showed: (1) long relaxation times; (2) no die swell; (3) the onset of shear dependence at much lower shear rates (due to molecular orientation at low shear stresses); and (4) in general, a very great dependence on shear history and thermal history.

The talk by Mr. F.N. Cogswell (ICI, Plastics Div.) was also concerned with the rheological behavior of liquid crystalline polymers, but his work involved both thermotropic melts and lyotropic solutions. He studied pressure-temperature relationships in extrusion processes involving aromatic polyester melts for the former and aromatic polyamide solutions for the latter. Important observations from his work were: (1) some polymers show thermotropic behavior

under shear but not in the relaxed state, and (2) a preshearing treatment of liquid crystalline solutions or melts considerably facilitates fiber spinning processes.

Prof. H. Ringsdorf (Univ. of Mainz, FRG) reviewed his well-known work on the preparation and properties of polymers containing pendant mesogenic groups. He was the first to show that the presence of flexible spacer groups between the main chain and the pendent mesogenic groups is an important controlling factor for achieving optimum liquid crystalline properties. The polymers developed by Ringsdorf and his associates show both nematic and smectic behavior, and they also have found that polymers showing cholesteric behavior with very interesting optical properties can be obtained by incorporating small amounts of chiral groups in the side chains. They have carried out extensive studies on electrical and magnetic field orientation of their polymers; of particular promise for the use of liquid crystal polymers in display systems is their very recent work on the preparation of both side-chain and main-chain thermotropic polymers containing polysiloxane units in the main chain. These polymers show nematic behavior at room temperature and below. They are now studying the inclusions of dyes into these polymers for improving their display properties.

Other talks presented at this conference were concerned with (1) the thermotropic properties of coal-tar and petroleum pitches of importance in the formation of graphitizable carbon, e.g. for carbon fibers, by Miss J.R. Lander and Mr. C. Atkinson (Univ. of Newcastle-upon-Tyne, UK); (2) polarizing microscopy studies of nematic polyesters, by Dr. M.R. Mackley (Univ. of Cambridge, UK); (3) thermodynamic and rheological properties of solutions of rod-like polymers, by Prof. G.C. Berry (Carnegie Mellon Univ., Pittsburgh, PA); (4) rheology of lyotropic solutions of cellulosic polymers, by Dr. P. Navard (Ecole des Mines de Paris, France); and (5) two talks on the mechanical properties of Kevlar fibers and fabrics by Dr. M.G. Northolt (Akzo Research, The Netherlands) and Dr. D. Kingston (ICI Fibers, UK).

The two-day conference was attended by approximately 70 people, mostly from the United Kingdom. (R.W. Lenz, University of Massachusetts)

## COMMUNICATION SCIENCES

### COMMUNICATIONS R&D AT SWEDEN'S TECHNICAL HIGH SCHOOLS—PART III

#### Chalmers University of Technology

Gothenburg has the dubious distinction of being the only city in Sweden considered "important" enough by the English to warrant having its name changed (from Göteborg). There is little doubt that its character and location (the busiest seaport in Sweden, and Sweden's closest city to England, by sea) qualified it for that honor. The city's character is dominated by the shipping industry, but it also has the air of an educational center, with groups of students milling about, from both the University of Gothenburg and the Chalmers University of Technology (CTH).

At CTH, I visited the Information Theory Department of the School of Electrical Engineering. Prof. Lars Kristiansson is the head of that department; he is assisted by Drs. Ingvar Jönsson and Per Hedelin.

Hedelin's research is in the field of speech signal processing. He is particularly interested in the application of Kalman filtering techniques to the problem of generating a good, low-data-rate, digital representation of the speech signal. The context within which this study is being conducted is the same national mobile communications project described in the preceding article on the subject (See ESN 34-12:552). Hedelin is hoping to design a cost-effective variation of the standard voice-excited vocoder. (That standard technique treats the lower-frequency ["voiced"] segment of the signal [usually called the "baseband"] as a general, not necessarily speech-related waveform which is sampled at its corresponding Nyquist rate; the upper-frequency ["unvoiced"] segment is processed by a channel vocoder-like subsystem [see ESN 34-11:503]). He proposes to reduce the overall transmitted data-rate by processing the voiced segment in a more complex manner, one related to pitch extraction and formant tracking. The system would use a multiple-Kalman filter approach to partition the total baseband, on an adaptive basis, into narrowband, non-contiguous subbands whose outputs would then be sampled at suitably reduced rates. The useful reduction in transmission rate which results from this approach is dependent upon the extent to which a significant part of the original speech bandwidth can be suppressed on an "instantaneous" basis by the filtering

process without degrading the quality unduly, and the degree to which that apparent advantage is not degraded by the need to transmit extra control data for use in the synthesis process. These questions, and also the question of the overall economic feasibility of this relatively complex approach, have not yet been resolved.

Jönsson's interest in information theory and coding is directed to the solution of an interesting problem in energy conservation. First some background: Sweden's general approach to the problem of energy conservation was described in a previous article, *ENR* 33-4:141 (1979). At that time, the referendum to determine whether the people of Sweden would commit themselves to the development of and dependence upon nuclear power sources had not yet taken place. Now that the decision has been made to proceed on that course, a new incentive for energy conservation has emerged: they want to reduce the number of such expensive and (possibly) locally-unpopular plants. To reduce the projected load, the Swedish Electrical Administration conjectured that, in conjunction with conventional physical approaches (e.g., insistence on the more general use of insulation, high-efficiency motors, etc.), the consumer would have to be made aware on a real-time basis of his/her individual economic interest in energy consumption. As things now stand in general, the ordinary energy consumer is not aware of the cost incurred for energy in time to take some action to compensate for an inordinately high rate of expenditure. For example, in Sweden, the energy (kW-hr) meters are read only once a year, but the consumer receives an estimated billing three or four times a year. Dependence upon the real-time observation of the meters themselves is generally not a feasible solution; firstly, they are usually in an inconvenient location, far removed from the living areas in an apartment house or private home; secondly, since the kilowatt-hour meter does not convey rate of consumption directly, the numerical display is not appropriate; and thirdly, since the cost per unit energy varies with both time and the total expenditure in many complex systems (e.g., with the time of day, or as different types of energy sources are "brought on line," or because of nonlinear characteristics in the rate structure), the kilowatt rate is not simply convertible to the consumer's out-of-pocket rate.

In an attempt to cope with the situation, Jönsson and several of his students have been active in the development of a system which uses the power lines, both

inside and outside the house, to transmit pertinent data to the consumer. A microprocessor-controlled "master" unit is located near the customer's existing meter, and data from the meter is fed to the master unit. The unit also interfaces with the outside world in the following ways: it receives data from the power distribution center which relate to time-dependent billing rates; it may be reprogrammed to compensate for nonlinear characteristics in the rate structure; and it responds to a polling command from the distribution center by transmitting billing data in the opposite direction. Inside the house, it uses the power lines to transmit data signals to all of the power outlets associated with the meter. Compatible digital display units are part of the system; those displays can be located anywhere within reach of an outlet.

Jönsson showed me a preliminary breadboard version of the devices involved; he and Kristiansson commented that the project plan calls for the production of about 5 million units! But before production can be started, several significant communication problems need to be solved. Measurements are being made by the Electrical Administration of the data transmitting characteristics of the power lines, both internal and external. The transmission medium must be characterized so that suitable codes can be devised by Jönsson to prevent inadvertent errors from occurring. Furthermore, cryptographic protection will be required to discourage and to detect larcenous attempts to defeat the system. In addition, modulation methods must be matched to the medium. For both the external and internal distribution systems, the expected impedance mismatches, noise bursts, power-line voltage surges, mutual-coupling effects, and other operational anomalies must be taken into account. This formidable set of problems sounded overwhelming at first, but Jönsson reduced the scope of the external segment of the problem by commenting that they plan to bypass the primary and most of the secondary power distribution network. Private-line telephone networks which run from regional centers to the secondary transformers are now used by the maintenance crews; their availability for double duty in the data network makes Jönsson's job considerably easier.

Lastly, he commented that consideration must be given to the possible interaction between the display data distribution signals and the clocks, radios, and other appliances, especially the microprocessor-controlled units, that are plugged into the data distribution systems, albeit somewhat inadvertently.

Before describing his own activities and research interests, Kristiansson described several other current projects within the Information Theory Department and others within CTH. In the area of robotics, they are developing a new robot arm system which they describe as a "buttons-and-thread" configuration. Instead of a conventional assembly of rigid links that are connected by universal joints, their link consists of a stack of curved discs, each of which has 4 holes. Cords pass through the holes and a microprocessor-based servo system controls the tension in each of the cords of each link separately, thereby orienting the arm in what could be a rather complicated trajectory. He described it as having the capability to pass through rather "small" holes and to reach around tight corners. The experimental unit (which was not available for a demonstration at the time) has a 10:1 load capacity-to-weight ratio, higher than that for any other robot arm that they are aware of.

In the area of aids for the handicapped, they are working on three other projects: a home-based Braille newspaper terminal (which will record at low-cost, nighttime transmission rates on a tape cassette for use in a Braille reproducer in the morning), and a pair of translators which convert Bliss-language transmissions into either picture data which is then fed into a standard TV set, or a speech-related signal which is fed to a speech synthesizer. (The Bliss language, developed by Charles Bliss, is an extensive array of symbols which are designed to be used by people with very severe speech impairments. By "pointing" to a series of these symbols in an addressable set of displays, the data thus generated enables the user to communicate rather rapidly over a standard telephone channel. It thereby extends the range of transmission of the conventional sign language used in face-to-face encounters.)

Kristiansson's personal research activity is related to the design of associative memory systems. He is resurrecting his interest in the subject, an interest which he put aside about 5 years ago. In this go-around, he is studying the application of truncated Hadamard codes for the data sequences and statistical assignment techniques for the location aspect of the problem.

Our discussions concentrated much more intensely, however, on Kristiansson's obvious interest in educating Swedish society, as a whole, on the subject of its future relationships with new technologies. He has pursued this crusade as an author of a prize-winning radio play and a number of other theatrical presentations, as an

actor in these productions, as a participant in TV panel discussions, and as an enthusiastic speaker before many political, technical, and general-interest groups. These pages in *ESN* do not lend themselves to a detailed discussion of his philosophical approach to the question. The evolution of many aspects of technology and society are portrayed by analogy, comparing concentrated configurations to distributed ones. For examples, he discusses as diverse a set of contexts as energy sources, household appliances, computers, control systems, communications, political systems, and labor relations. A visitor to his department cannot help being impressed by the degree to which that group is tending away from abstract functions and equations. Walking down the corridor in the School of Electrical Engineering toward Kristiansson's office, the visitor passes the offices and laboratories of the Network Theory Department where the exhibits in the hallway display microwave stripline devices, computer-generated transfer functions, etc. Then, as one enters the region assigned to Kristiansson's department, the exhibits change abruptly. Sociotechnology is the theme. Technology is indeed being pursued within the offices and laboratories, but the impression I received was that those studies had better relate to an identified societal need, because...that's where it's at.

#### Lund Institute of Technology (LTH)

In the course of visiting the set of cities and institutes which make up the itinerary of a liaison trip, there is a natural tendency to make comparisons between the different places visited. The short stays involved (many times, only one day per place) do not lend themselves to the development of extensive, detailed impressions of the local environment. Most of the comparisons that develop are only with respect to the set of places visited as part of that particular itinerary. But Lund was different; we found ourselves comparing it to Ann Arbor in the 1950s. The old campus with vine-covered buildings on broad tree-lined streets, the central "quad", a new engineering school on the outskirts, and the big city about an hour away by car all seemed to enforce the resemblance.

In the other cities visited as part of my tour of Sweden's technical universities (Stockholm, Linköping, and Gothenburg), the impression gained was that, while the university/institute was a recognized segment of the overall community, it was not the bedrock upon which the whole community was based. But again, Lund is different. The University of Lund was founded in 1666, less than ten years after the Scanian provinces (the southernmost

part of present-day Sweden) were acquired after one of the many wars with Denmark in the 16th, 17th and 18th centuries. The university was meant to provide a unifying influence between the newly-acquired region and the northern provinces. Uppland had its university in Uppsala which had been founded in 1477; Skane's university in Lund was organized originally as a faculty of theology, adding liberal arts, law, and medicine soon thereafter. Today, the university includes 8 faculties. The newest one, in technology and known as LTH, was founded as a separate entity in 1961 and was made part of the university in 1969.

My host at LTH's School of Electrical Engineering was Prof. Göran Einarsson, head of the Department of Telecommunication Theory. Within his department's area of interest, 3 projects were discussed: the work of Assoc. Prof. Carl-Erik Sundberg, Dr. Tor Aulin, and Göran Lindell on digital signal modulation techniques; a signal processing project which was carried out by Per Ola Börjesson in conjunction with the medical faculties of the university and a nearby hospital; and Einarsson's own research on coding for frequency-hopping spread-spectrum communication systems.

Besides the researchers in his department, I met members of two other departments: Assoc. Prof. Rolf Johannesson, of the Department of Automata and Computer Engineering, who has been working on cryptographic problems lately; and Ulf Körner, a doctoral candidate in the Department of Telecommunication Systems, who, together with at least six other researchers in that department, has been studying the characteristics of large digital switching complexes.

The work of Sundberg and Aulin has been reported upon quite extensively in the proceedings of conferences sponsored by the IEEE's Communication Society and its Information Theory Group. The digital modulation/demodulation (modem) techniques which they have been studying are of a class which has, as functions of time, an envelope characteristic with constant amplitude and a phase characteristic which is continuous. The former characteristic is desirable for use with the sort of nonlinear amplifiers often found in practical transmitters and/or with transmission media that exhibit fast fading characteristics. The latter characteristic is useful in controlling the spectral spreading introduced by the phase modulation. The price paid for introducing the requirement for continuous phase in a time-discrete signalling system is the need for extra complication in the process at the receiver: the

optimum detector for such a signal in the presence of noise must observe the signal over a longer period than one symbol interval to decide on each symbol's value, even for those cases where no correlation exists between data symbols.

Their studies have resulted in estimates of signal spectra and symbol error probabilities for a wide range of basic modulating waveforms, modulation indices, symbol bit rates, detector configurations, and observation times. Beside its general interest to the field of communications, this activity is yet another part of the previously-described effort toward the development of a national mobile digital communication system which is being proposed in Sweden: LTH is studying the modem techniques while CTH studies the speech coding aspects and Linköping studies the characteristics and implications of the transmission medium. (The overall system tradeoff decisions and the practical implementation are the responsibilities of a group at SRA Communications, an industrial organization in Spangå, Sweden, who have been supporting these efforts since 1976.)

The medically-oriented signal processing project, which was referred to previously, relates to handling electrocardiogram (ECG) records. For certain types of ambulatory heart disease patients, a long-term continuous record of the signal is desired for diagnosis. Olle Pahlm of the University's Department of Clinical Physiology had recently devised a computer-aided signal analysis system for such records, but the normal PCM data rate associated with the ECG signal was too high for efficient storage in the computation center. The center was limited to the use of cartridge disk-packs, each of whose discs have a 2.5 Mbyte capacity. That corresponded to the capacity for handling only about 5 hours of raw recorded ECG data together with its associated processed data; but for logistic reasons, a 12-hour capacity was required. A data compression system was needed for converting the raw digital data from a rate of 800 bits/sec (at 100 samples/sec) to about 350 bits/sec without degrading medical quality. Börjesson has designed such a system and it has been shown to be clinically suitable after use on over 600 12-hour records.

The overall compression comes about in two steps. A predictive coding scheme is used to remove much of the redundancy between successive samples. The residues developed in this step of the process are then converted, on a single symbol basis, to a variable-length code which provides a further reduction in average data rate. Each of the residues so encoded is the

difference between the quantized measured sample value and that value predicted for the sample, based on the values of previous samples. To avoid undue complexity while achieving the goal of a 12-hour capacity, simple linear extrapolation of the two previous samples was used in Börjesson's system. His analyses showed the degree to which extra compression would have been available at the expense of more complexity in the form of non-linear predictors. The variable-length symbol code which was used was not a Huffman code; such a code would have been optimum if they had considered it worthwhile deriving the necessary probability distribution of the residues on a record-by-record basis. But for the very long data streams involved and with the expected variability between patients, that procedure was not considered suitable. Instead, a simple variable-length code, common to all records, was implemented. While the expected reduction from optimum compression did occur, their successful experience in the clinical trials appears to support the decision to compromise.

Einarsson's interest in codes for multiple-access spread-spectrum communication systems was sparked during a recent sabbatical leave that he spent at Bell Labs. His first paper on the subject appeared in the September 1980 issue of *Bell System Technical Journal*. In that paper, he treats the problem of assigning digital addresses to a set of simultaneous, but not necessarily synchronized users of a frequency-hopping modulation system. Ambiguities leading to errors in the decoded symbol can occur as a result of interference when the number of users becomes too large. In those reported studies, Einarsson had only considered the problem on a symbol-by-symbol basis. He now hopes to generalize those studies to include consideration of methods whereby redundancy present in multi-symbol messages can be used to resolve those ambiguities.

My discussion with Prof. Johannesson in the adjoining department was highlighted by a preview of material that he will be presenting at the IEEE International Symposium on Information Theory in Santa Monica next month (February, 1981). He and his colleague from the Department of Mathematics, Prof. Tore Herlestam, have developed a new heuristic algorithm for computing logarithms over the finite field of  $2^p$  elements,  $GF(2^p)$ . The significance of this development might be expressed by quoting the title of their paper: "On Computing Logarithms over  $GF(2^p)$  or an Attempt to Swindle MITRE Corp." The basis for such a melodramatic admission of guilt is that their algorithm's suc-

cess in tests that have been run so far implies that a public-key cryptographic system being implemented by the MITRE corporation may not be secure. The system's claim to cryptanalytic security is based upon an assumption that the process of computing such logarithms is very time consuming and therefore impractical for the case that they are implementing, namely where  $p$  is equal to 127 (i.e.,  $2^7-1$ ). The new algorithm has been tested by Johannesson and Herlestam for many hundreds of randomized chosen elements for cases where  $p$  equals 13, 17, 19, and 31. So far the attempts have all been successful, with only a few seconds of running time required on a modest computer for the cases when  $p$  equals 31. At the time of our discussion, they were looking forward to testing for  $p$  equal to 63. Perhaps, by the time the work is described in February, there will be some specific results announced for the case of one more exponential step closer to 127.

When we discussed the matter, Johannesson was not quite sure *why* the algorithm was working so well; Herlestam was attempting to justify the situation on theoretical grounds but hadn't yet been successful in explaining their success. The heuristic approach they had taken just worked. (I shall not "scoop" the authors on these pages by describing their algorithm before they do.)

My last stop at LTH involved a visit to the Telecommunications Workshop, sometimes called the Department of Telecommunication Systems. Körner described the group as one which, 10 years ago, busied itself with consideration of telephone networks in general and traffic statistics in particular. Now, however, they are heavily involved in computer simulation of computer networks, with an emphasis on ARPANET-like packet switching systems. The researchers in the Department are supported by the L.M. Ericsson Company to a significant level (see ESN 34-12:556 [1980]). Ericsson's AXI electronic switching system is the existing configuration which they are simulating rather extensively. The project has been going on since 1977 and is expected to continue for at least 3 more years, resulting in the architectural design and simulation of a new generation of electronic switching systems. Körner has been concerned with the polling aspects of the system, namely the protocols under overload conditions, the delay times to be expected under a variety of conditions and the criteria of acceptance for the systems. Others in the group are considering a wide variety of system problems: flow control, regulation of incoming

traffic, priority disciplines, models for queuing, diffusion, the effects of burst traffic and other types of load variations, the use of redundancy in the system hardware, and the effects on the system of the use of different processor units.

Sweden's institutes of technology have a reputation for excellence, so finding excellence there was not surprising. The thing that did surprise me was the level of cooperation and mutual support between what might, elsewhere, have been competing groups at the four locations. Perhaps Prof. Ericson's comment (made during my visit to Linköping) would help to explain why this is so: about 15 or 20 years ago, the four men who had been my hosts at their respective schools were together as students under Prof. Zetterberg at the Royal Institute in Stockholm. Familiarity appears to have bred cooperation. (Philip Fire)

#### TWO INTERVIEWS IN CAIRO CONCERNING SCIENCE AND TELECOMMUNICATIONS

My first interview in Cairo was scheduled to be with Dr. I.G. Badran, who in the past was considered to be Egypt's foremost surgeon and who is now president of the National Academy of Sciences and Technology. Badran had, however, been called away for a meeting with President Sadat, and I was graciously received by the vice-president, Dr. M.B.E. Fayez. Fayez' field is organic chemistry. He received his PhD from the University of Glasgow and spent 4 years at various universities in the US. Fayez described the organization of the academy to me and stressed that the inclusion of technology in its title was meaningful. The academy is a government body under the Ministry of Education and Scientific Research but it also interacts with other government departments. It plans and supports scientific research in the country which is supplementary to that of specific government departments and to institutional research. The preferred types of projects are those that are of an interinstitutional nature and that are also of interest to more than one section of the country. Funding, which is obtained directly from the Egyptian government and also from foreign sources, amounts to an annual total of about \$11 million. A number of current projects are being funded directly by the US, e.g., by USAID (United States Agency for International Development) or the National Science Foundation, even though project initiation came from the academy.

Projects are reviewed and selected by the Research Council, which is made up of specialists in various fields from outside the academy. The projects may be conceived anywhere and the initiatives for submission, which may come from the council itself or from outside, often are tailored for the participation of specific institutions. The final decision and selection is made by the Academic Council. About 40% of the available funds are allocated to universities, 40% goes to the special purpose R&D institutions affiliated with ministries, and the remaining 20% is assigned to institutions that are affiliated with the academy: 7 specialized institutions (e.g., the Petroleum Research Institute and the Institute of Fisheries and Oceanography) and one general institute, the National Research Center. Currently, over 190 projects are being supported.

Fayez commented interestingly on the position of Egypt within the Arab world. Aided by Egyptian TV programs and films distributed throughout the Arab countries, the Egyptian type of Arabic is widely understood. Egyptians, therefore, easily fit into the other Arab countries, and Egypt has become a large labor reservoir, especially for skilled labor, supplying the whole range of demands from policemen to university professors, administrators, and high court judges. Some 2 million Egyptians (about 5% of the population) are estimated at this time to be working outside Egypt. This presents a ready market for the continuous absorption of trained people. The University of Cairo alone has some 140,000 students who eventually will seek employment, many in other Arab countries.

My second interview was at the Arab Union for Telecommunications. I was received by its chairman, Dr. Mahmoud Mohammed Riad, a man of considerable stature who has had an interesting career. He studied at the Imperial College in London under Willis Jackson; worked on early microwave TV links for the Standard Telephone Laboratories in England; taught at the University of Alexandria; joined the Egyptian Telephone Administration, ending up as its director; was minister for telecommunications in Egypt; became professor of electronics at the Kuwait University; returned to Egypt and again became minister of communications in 1971; and relinquished that post to become chairman of the Arab Union of Telecommunications. He described the Arab Union as an organization making an earnest effort to combine the needs in this vital field for all Arab countries. There are 20 members, but because of the present political tension and strife,

only 3 of those members are participating actively; the other 17 are boycotting the organization. Riad discussed telecommunications in Egypt. It was he who had initiated a move to a digital microwave system connecting 2 telephone centers in Cairo. The specification for this system was written by the Ministry of Communications and some funding from USAID was available. The contract was awarded to the Raytheon Company, which supplied and installed the equipment. It now carries most of the intracity load since the underground cables are in poor condition. Microwave links will eventually connect other parts of the country.

Within the city of Cairo itself, there are certain communication difficulties due to the fact that two different switching systems, rotary and cross-bar (which are not quite compatible) are in use at this time. The present aim is to install electronic switching equipment, and a beginning has now been made to accomplish this.

TV channels and transmissions come under a different government department that acts independently, as do many other organizations that have their own communications systems; these include the Suez Canal Authority, which looks after the needs of the canal, and the Ministry of Petroleum, which controls the oil pipeline (SUMED), from Suez to the Mediterranean. The pipeline supplements the canal, which is too shallow for supertankers. A considerable amount of very active prospecting for minerals is carried out by organizations that have their own communications systems. They have found gas and oil, mostly offshore and in the desert, and Egypt has become an oil-exporting country. (T. C. Cheston)

## EARTH SCIENCES

### METEOROLOGY AND CLIMATOLOGY IN GREEK UNIVERSITIES

The Department of Meteorology at the University of Athens is based on the German system with 1 professor (currently Dr. D. Lalas), and a total of 14 scientists, 8 of whom are senior assistants (the rough equivalent of our assistant and associate professors).

Although Lalas is a native Greek, he received all of his college and university training in the US. He has a PhD degree in aerospace engineering (fluid dynamics) from Cornell and he

taught in the Mechanical Engineering Department at Wayne State University from 1968 until last year. In the 1979 volume of *American Men of Science*, he lists his speciality as dynamic meteorology. His primary research interest is in the dynamics of micro- and mesoscale gravity waves in the atmosphere, their excitation, stability, and properties, and the physics and dynamics of 2-phase flows in the atmosphere and the laboratory. In addition to his work in the Department of Meteorology, he teaches 2 courses in dynamic oceanography to students working on their MSc degrees in marine science.

There is a 2-year MSc course, with a full curriculum, in meteorology. From 10 to 15 students enroll in this course each year. There is no formal course work for the PhD degree. At present, there are 5 PhD candidates.

Because funding for such gravity-wave research is hard to come by, Lalas is planning a series of studies on the air-sea-land boundary. He is interested in the atmosphere and what happens to the boundary layer when the bottom boundary changes roughness at or near the coastline. He plans to use an inverted acoustic sounder mounted on tiny half-meter-high islands near the coast. With this instrument he can determine the heights of near-surface inversions and he can see how these inversions react to changing surface roughness.

The research program within the department consists of the following activities: (1) gathering climatological statistics for Greece including air temperature, humidity, rainfall, and snow; (2) developing solar energy maps of Greece for both meteorological radiation budgets and determining how much energy is available from the sun; and (3) monitoring air pollution at various locations in Greece and developing mathematic models to study flow fields and diffusion patterns. While I was in Lalas' office, someone from the Ministry for the Environment phoned to discuss a proposed research project for the Department of Meteorology which would be concerned with acid rain. A complex of heavy industries near Athens is polluting the atmosphere with sulfur dioxide, which becomes sulfuric acid when it is washed out of the atmosphere. This acid is causing a great deal of damage to the ancient marble monuments of Greece.

A brief list of the other members of the department and their areas of specialization follows: Dr. Karalis, reader, radiation, climatological studies; Dr. Asimakopoulou, reader, remote sensing in the atmosphere, boundary layer meteorology; Dr. Karras, lecturer, climatology, air pollution; Dr. V. Notaridou, lecturer,

cloud physics, atmospheric radiation; and, Dr. D. Pissimanis, lecturer, synoptic meteorology. There are three other junior staff members with recent PhD degrees working on climatological studies of various parts of Greece. Three graduate assistants are working on atmospheric gravity waves and the sea breeze.

Prof. J.D. Zambakas is chairman of the Department of Climatology at the University of Athens. A course in general climatology is taught to about 120 undergraduate students who are majoring in biology or geology. About 20 graduate students with undergraduate degrees in mathematics and physics are working for advanced degrees in climatology. They are offered 9 different courses in climatology.

Research is underway in bioclimatology, urban climatology, air pollution, and radioclimatology. There are ongoing projects to determine the space and time distribution of hailstorms, frost, sunshine duration, and precipitation over Greece. The department is working on protection measures against hail, frost, wind, and floods. Climatology is being used in the selection of better radio links over Greece. It is also being used as a criterion for the selection of sites that are suitable for exploitation of solar and aeolian energy.

Dr. D. Metaxas is professor of meteorology in the Department of Physics at the University of Ioannina in northwestern Greece. He teaches four elective undergraduate courses in meteorology which may be taken by students who are majoring in mathematics and physics. Students with bachelors' degrees in mathematics and physics can work toward the PhD degree under his direction. However, he prefers to send potential new members of his research group abroad to obtain their advanced degrees. Two received their MSc degrees in the United States last year and one of them is now working on his PhD degree.

Metaxas has worked on a wide range of research topics. These include: linear models of the mean monthly air temperature over Athens; strong cold invasions in the Aegean during the winter; air-sea interaction in Greek seas; the correlation between air temperatures in Athens and central England; the importance of adiabatic heating and divergence in the Mediterranean; annual models of river discharge; persistence of monthly temperatures in Greece; the characteristics of the etesian winds (summer winds from the north over Greece); and case studies of the effects of peculiar, strong, local winds on ancient sea battles near Greece. (Wayne V. Burt)

## ENGINEERING

### ANECHOIC CHAMBER PAR EXCELLENCE; REMOTE SENSING AND OTHER GOODIES FROM DENMARK

A visit to the Acoustics Laboratory of the Technical University of Denmark (TUD) was described in a recent issue of these Notes (ESN 34-11:511 [1980]). In the present article, I describe a visit to the Electromagnetics Institute situated on the same campus just outside of Copenhagen. The Electromagnetics Institute is part of the Electrical Engineering Department, which has about 1,500 students. The institute has 11 professors or associate professors, and about 15 graduate students, most of whom have TUD grants. The professors spend about 50% of their time teaching, 40% in research, and 10% on administration. They have complete freedom in choosing the research work they wish to carry out, but this freedom is tied by the thin, silken thread of monetary control. Monies received from sources outside the institute are put into a pool. The distribution of funds from this pool is then determined by the institute as a whole, with all members participating by vote in the decision. The head of the institute is elected with similar democratic procedures and need not even be a member of the scientific staff. At the time of my visit, the head was an associate professor. It seems that such a system would be fraught with dangers and that funds received for one purpose might be spent for another. In actual fact, the system seems to work well and in harmony. Perhaps it engenders cooperation and good will without which no system can survive successfully.

Prof. Jørgen Appel-Hansen's primary interest is in the measurement of microwave antennas. At this time he is writing the antenna-measurement chapter of a new UK handbook, *Principles and Applications of Antenna Design* edited by A.W. Rudge, and expects to have the manuscript ready by the end of 1980. He has spent much time perfecting near-field antenna measurements and operates a large, anechoic chamber. This chamber is used for internal research work but most of the time it is leased, with or without professional staff to help, to outside organizations, ranging from the Moscow Power Institute in the USSR to the National Science Foundation in the US, from the Tanta University in Egypt to the Post Office in Norway. About 60% of the cost of building the anechoic chamber was carried by the European Space Agency (ESA) and much of the equipment is owned by them.

Many of the activities have centered around near-field testing of antennas. The field in close proximity to the antenna aperture is scanned with a small probe and the far-field response of the system can then be calculated. The probe can be made to travel in a raster on a plane surface (planar scanning). Alternatively, it may just move up and down while the antenna under test rotates in azimuth (cylindrical scanning). Lastly, the probe may be moved on the surface of an imaginary sphere (spherical scanning) with the antenna at its center (or the probe may be held still and the antenna pivoted about a point). These techniques are convenient to use and have been shown to be capable of giving considerable accuracy in the prediction of radiation patterns, including side lobes. The directivity can be calculated very accurately. In one test it was measured in 3 different ways with a probe 1.5, 2.5, and 5 m from the aperture, giving a predicted directivity of 36.85, 36.88, or 36.85 dB respectively. Low radiation levels where substantial field cancellations occur are, of course, predicted with less accuracy. The calculations do include a correction term for perturbations caused by the probe itself.

Annel-Hansen has published methods of calculating the far-field pattern from planar, cylindrical, and spherical near-field scanning antenna measurements, and also gave a course on the subject in the summer of 1979 at the California State University, Northridge. In January 1981 he will lead a course which will be held in Lyngby sponsored by TUD, the US National Bureau of Standards, and ESA.

The anechoic chamber measures  $8.8 \times 10.0 \times 12.4$  m on the inside. It has a "quiet zone" 2.5 m in diameter and 9.5 m long and is useful for measurements from 100 MHz up. It is completely shielded. The absorber was obtained from Emerson and Cuming. The chamber was demonstrated to me by J.M. Lemanczyk who comes from the McGill University in Montreal, Canada. It is used for measurements of antennas, radar cross-sections from models or actual targets, and measurement of noise from electrical installations (down to 50 MHz). The chamber contains precision equipment for mechanically positioning antennas weighing up to 2 tons with an accuracy of 0.1 mm for spherical near-field measurements, and for all normal types of antenna rotations for other measurements. The whole facility is fully instrumented and computer controlled, with effective and efficient software for near-field/far-field transformations and probe compensations. Measurements are also computer controlled and include self-

tracking programs. Response to two orthogonal polarizations can be measured at one time. All this instrumentation is aimed at making the chamber an antenna standard facility for ESA. A smaller anechoic chamber is now being built to relieve the workload.

Other work in Appel-Hansen's antenna group includes that by Torkeld Hansen, who is studying the near-field of a sphere used as a scatterer. The results seem to indicate that the phase center is at a distance of about half of the radius behind the aperture.

Jørgen Hald is investigating another method of measuring an antenna in a confined space. An illumination antenna is used to generate a planar field near its aperture and the antenna under test is placed into that field and rotated for pattern measurements. Hald is investigating the problem theoretically to find the best way of generating a flat field at a compact range. He is beginning to get good results with an aperture formed by eight radiators forming an octagon, 12 wavelengths in diameter, and with a ninth radiator at the center. Ernest Krogerer is working on still another problem. He is investigating the effects of various forms of vegetation on the propagation of electromagnetic waves.

Prof. Preben Gudmansen heads a research group working on remote sensing systems. Niels Skou from that group described to me the radiometric measurements of sea ice in the Greenland area with 5, 17, and 34 GHz airborne systems. The work was supported by the US National Science Foundation and the Ministry of Greenland. All three radiometers had overlapping footprints, nominally  $500 \times 170$  m in size, obtained from microwave horn antennas. A high resolution scanning antenna could be substituted. It was found possible to distinguish between water, thin (first-year) ice, and older ice. Ice maps showing this differentiation are of importance to shipping. Another remote airborne investigation of ice in Greenland and other areas was described by Skou where the thickness of the ice was measured with 60 and 300 MHz radars. A measurement of 20 m accuracy was claimed for ice depths less than 3,000 m. In a cooperative Danish/US effort, holes were drilled to examine the ice and recover some of the history locked in at the time that it was formed.

Gudmansen's group also participates in another program to investigate Greenland's ice. This program was part of Canada's SURSAT project which had US and British participation. Measurements of the marginal ice zones were carried out from five aircraft with microwave,

infrared, and optical sensors. Additional ground information was obtained using helicopters.

In still other investigations, a real-aperture, side-looking radar mounted on an Otter aircraft is used for mapping. Gudmansen described much of the remote sensing work in "Electromagnetic Studies of Ice and Snow" published as proceedings of the seminar, "Remote Sensing Applications in Agriculture and Hydrology," ISPA Establishment (Varese, Italy) 1980. (T.C. Cheston)

#### UK EISCAT USERS SCHOOL AT THE UNIVERSITY OF LEICESTER

Two years ago the first UK EISCAT (European Incoherent Scatter Auroral Radar) School (i.e., course) was held at the University College of Wales, Aberystwyth. The purpose of the course was primarily to educate UK scientists and graduate students in the powerful techniques available to them by remotely sensing the auroral atmosphere with an incoherent scatter radar. The radar consists of high-power UHF and VHF transmitters using high-gain antennas, situated in Tromsø, Norway and matching receivers situated not only in Tromsø but also in Kiruna, Sweden, and Sodankylä, Finland for bistatic scattering information. The UHF program is about 2 years behind schedule due to manufacturing difficulties encountered by the US contractor responsible for the transmitter. Installation is hoped to be completed by the end of 1980.

The second "EISCAT School" took place from 22-26 September 1980 at the University of Leicester. At that time, the UHF transmitter had not yet been installed in Norway. To provide a greater degree of practical experience to those assembled, two American experimenters were present: Prof. Joe Doupnik (Utah State Univ.) and Dr. Jim Vickrey (SRI [Stanford Research Institute] International). Both have worked with the incoherent scatter radar at Chatanika, Alaska, as well as with those at Jicamarca, Peru, and Arecibo, Puerto Rico. Material covered at the school included an introduction to EISCAT, description of the available facilities, experimental techniques, data analysis, results to be expected, and types of programs.

Six European countries, the UK, FRG, France, Norway, Sweden and Finland, contribute to EISCAT and form the European Scatter Scientific Association. Governments are involved only to the extent that they are the ultimate sources of funds

for the various member science research councils which fund EISCAT programs. Funds are provided in the following proportion: UK (25%), FRG (25%), France (25%), Norway (10%), Sweden (10%), and Finland (5%). Observation time for member country usage is also apportioned in that relationship.

Headquarters of EISCAT and the data bank are in Kiruna. The primary site at Tromsø has a VHF (224 MHz) transmitter/receiver using a cylindrical 4800 m<sup>2</sup> antenna, and a UHF (933.5 MHz) transmitter/receiver using a 32-m diameter dish antenna with computer driven controls. The secondary bistatic sites in Kiruna and Sodankylä are provided with 32-m dish antennas for UHF reception only, steerable in both elevation and azimuth. The large VHF antenna is divided into four independently maneuverable panels. It is steerable in the North-South magnetic meridian. Due to phasing flexibility, the VHF beam is also steerable up to 25° from the magnetic meridian in the East-West direction. Split-beam operation is also an option.

All sites are connected with land-line data links to Kiruna. The Tromsø site also has major complementary non-EISCAT installations such as the Max-Planck Institute's Ionospheric Heating Facility, and the University of Tromsø's Partial Reflection Experiment, plus several related geophysical sounding and monitoring facilities.

Measurable properties of the scattered radiation are power density, spectral shape, and frequency shift. From these, the electric field can be calculated as a function of height, and the ionospheric conductivity, neutral wind velocity, neutral temperature, and the downward heat flux from the outer ionosphere can be determined.

The EISCAT Annual Report for 1979 lists some possible results of the active (transmit/receive mode) experiments:

- (1) Clear detection of polar wind outflow.
- (2) Map currents, electric fields, and temperatures through an auroral arc.
- (3) High time-resolution density profile through the D- and E-Regions as associated with rapid variations in particle flux.
- (4) Clear identification of the "images" of the polar cleft, the plasma sheet and plasmopause in the ionosphere.
- (5) Measurement of convection patterns within the polar cap.

Observation programs are of 2 types: common and special. Common programs will consume half of the observing time and will provide diverse data to all EISCAT member countries, with 4 dedicated observing days per month or 24 hours per week. The first common program has been

selected, as stated below, and a further 2 have been proposed but are not yet definite.

Special programs will use the other half of the available observation time. As previously noted, these times are apportioned to EISCAT member countries in proportion to their contributions. Each country then selects observing programs from proposals submitted by member scientists. In principle, each country has sole authority over the observation programs conducted during its allocated time. Investigators are encouraged, however, to collaborate across national lines and thus gain more observation time.

Some UHF common programs that are under consideration are:

(1) Tromsø Field Line: measurements of ionospheric parameters at 40 points between 100-500 km and 700-1000 km along the UHF beam, pointed along a magnetic field line. Velocities will be measured at 3 points along a beam in sequence by Kiruna and Sodankylä antennas. Cycle time is to be approximately 5 minutes. This program is now firmly established.

(2) Three-Direction Program: pointing the Tromsø beam in 3 directions in sequence and measuring parameters at about 40 points along the beam, while Kiruna and Sodankylä measure at 2 heights in the E- and F-Regions. Cycle time is to be about 6 minutes. The 3 directions suggested are 30° N, zenith, and 30° S. This program is still in the flexible stage and may be altered somewhat.

(3) Meridian Scan: measure electric field as a function of latitude at 300 km height at several points covering the whole range of the UHF system. Cycle time is to be about 20 minutes. The several points may be North and South, or points North only. This program is still in the very early stages of consideration.

The common programs will run for approximately 6 months before a final decision is made as to their validity. Once that point is passed, common program observations will be run, unchanged, for a period of up to 10 years. At this time no common programs for VHF frequencies have been considered but suggestions are being solicited.

Several other topics were covered briefly during the course: SABRE (a creative acronym for Sweden And Britain Experiment) which will be operational early in 1981. This is a much-improved STARE-like bistatic radar based in Wick, Scotland, and Uppsala, Sweden, with which real-time observations of auroral irregularity drift velocities will be made. The University of Leicester is the key organization for

development and installation of the SABRE facilities. The Chatanika radar will be moved to Sondre Stamfjord, Greenland, in 1982. Efforts are being hurried to make cooperative EISCAT/Chatanika observations before that move is made. The OPEN (Origin of Plasma in the Earth's Neighborhood) four satellite program (1986) has solicited collaboration with EISCAT, and as a result, EISCAT headquarters has sent a list to NASA of possible cooperative observations.

The next EISCAT School (1982?) will probably be more of a workshop of results gained and lessons learned. It may be noted that there is considerable interest in EISCAT by non-EISCAT nations. Several US investigators are eager to collaborate in EISCAT observations, as are those in the USSR. There has been some suggestion by the USSR of joining the EISCAT Scientific Association by establishing a fourth site near Murmansk. (David T. Newell European Office of Aerospace Research and Development [AESR])

## **MATERIALS SCIENCE**

### **COMPOSITES III**

Over the past few years I have become fascinated with an aspect of material science that might be called "the mechanical properties of biological materials." This fascination largely began when I came into possession of a book by S.A. Wainwright, W.D. Biggs, J.D. Currey, and J.M. Gosline, entitled *Mechanical Design in Organisms* (Chichester, UK, John Wiley & Sons, Ltd., 1976).

The first chapters of this very readable book are devoted to reviewing the basic chemistry, physics, and mechanics of inorganic and polymeric materials. Because nature makes so much use of composite materials in all kinds of forms, much attention is given in the early chapters to the basic principles of composites. But the good stuff comes in the later chapters which reveal—so far as it is known—how nature ingeniously organizes matters at the molecular and macroscopic levels to achieve very specific properties.

I visited one of the authors of the book, Currey, in the Department of Biology, at the University of York, UK. Currey was trained as a zoologist at Oxford where he did work on hard invertebrate materials. At York he spends half of his time on bones (partly in collaboration with Dr. N. Bonfield at Queen Mary College, Univ. of London) and the other half on invertebrate materials. As a zoologist, Currey feels that he has an advantage in understanding the mechanical structure of biological materials because, although most materials

people understand mechanics, they have a great deal of difficulty with biology. This is a bit unfortunate because nature has a lot to teach us about how to put together rather ordinary substances to obtain some unique properties.

Currey's work on the mechanical properties of mother-of-pearl illustrate this point rather well. Mother-of-pearl, or nacre, as it is known to biologists, is more or less typical of the skeletal structures of shellfish. Nacre is 99% calcium carbonate: a rather brittle mineral with a fracture energy of about  $0.2 \text{ Jm}^{-2}$ . Nacre, on the other hand has a fracture energy, as measured by Currey and others, of  $150\text{--}1,650 \text{ Jm}^{-2}$ . Currey has done a detailed study of the structure and the mechanical properties of nacre (see, for example, *Proc. R. Soc. B* 196, 443, [1977]) and has shown that it is composed of calcium carbonate platelets held together by a very thin layer of protein "glue". Nacre has a modulus of  $10\text{--}60 \text{ MNm}^{-2}$  and tensile strengths of  $40\text{--}100 \text{ MNm}^{-2}$  depending on the species. These numbers are what one would expect for calcium carbonate but, unlike the mineral, nacre does not exhibit brittle fracture; instead it shows a distinct plastic yielding region in its load-deformation curve. This fracture resistance comes about because of the way the calcium carbonate platelets are stacked (which promotes crack-blunting) and the viscoelastic properties of the protein matrix. The chemical and rheological properties of the organic matrix do not seem to have been determined as yet.

According to Currey, nacre seems to be a primitive structural type found in those species that have undergone relatively little evolutionary diversification or modification. The evolutionary pattern has been towards weaker shells in favor of faster growth rates; the oyster is an example of a more "advanced" species. These evolutionary patterns have caused Currey (see *ESN* 34-12:563 [1980]) to investigate what he calls "optimizing strategies" of shellfish and other invertebrates. For example, whelks in Anglesey (Wales) in more exposed shore regions have stronger shells for protection against crabs than those that are less accessible to predators. Barnacles, growing near the sea-air interface, that are continuously battered by waves, actually have weaker shells than those below the tide level because the latter must protect themselves from attack by fish. Currey feels there has been a lot of guesswork about the design of shellfish and invertebrate structures in general, and that much of this "common knowledge" does not hold up under close scrutiny. Part of his current

research is concerned with the shape of shellfish and with determining whether the design is for high strength, burrowing, or rapid growth. Using strain gauges and photoelastic techniques, he is looking at the stress distribution when load is applied to various types of shellfish. He would like to use computerized finite element analysis (FEA) to simulate stress distribution, but this takes too much computer time—besides, zoologists are not supposed to need computers. He does use FEA in a limited way to determine maximum strain regions and then confirms the calculated results experimentally.

One of the most elegant shellfish, both in appearance and design, is the nautilus; that helically shaped creature that can withstand the hydrostatic pressures encountered hundreds of meters deep in the ocean. It has been taken to depths of 600 m without suffering collapse. The nautilus shell is designed for optimum stress distribution. The wall stress produced by hydrostatic pressure is proportional to the radius of the wall and so the nautilus shell wall is thickest where the radius is greatest. Engineers designing deep-sea vessels have not been unaware of the design principles of the nautilus.

Although most of Currey's work in vertebrate structures has been concerned with shellfish, he is beginning to turn his attention to insects. He draws an interesting analogy between crabs and automobiles, on the one hand, and insects and airplanes on the other. Crabs (shellfish in general), like automobiles, are constructed from energetically inexpensive materials. Crabs are composed of calcium carbonate with a minimum of proteinaceous material, and until recently, automobiles were built from inexpensive steel. But as steel becomes more costly it is not entirely coincidental that it is being replaced by organic composites containing large amounts of calcium carbonate reinforcement. By way of contrast, the structural requirements of insects, especially the flying varieties, demand the use of energetically expensive protein for its special elastic and viscoelastic properties. Similarly, energy-intensive aluminum alloys have been the materials of choice for aerospace construction, but such alloys now are being replaced by the even more costly titanium or by graphite-reinforced composites. Currey plans to take an in-depth look at the structure of insects, and he expects that there will be some lessons for material scientists and design engineers.

The oldest and perhaps most widely-used composite is, of course, wood. It has its shortcomings: poor strength in compression, high water absorption, and vulnerability

to biological attack. However, unlike fiberglass or continuous glass-fiber and graphite-fiber composites, wood is highly resistant to splitting and with simple precautions it can be nailed, screwed, and cut. This resistance to splitting is reflected in the high fracture energy of wood;  $10^4 \text{ Jm}^{-2}$ .

The microstructure of wood and the reasons for its high toughness have been the subjects of considerable study for many years. Two of the people very much involved in these studies are Prof. J.E. Gordon and Dr. Giorgio Jeronimidis (Univ. of Reading). Gordon is professor of materials technology and he and Jeronimidis are in the Department of Engineering. Gordon is well known for his work in material science, especially for the Cook-Gordon failure mechanism in composites (cracks propagating transversely to the reinforcing fiber are blunted by debonding along a weak matrix/fiber interface (*Proc. R. Soc. A282*, 508, 1964)). Gordon, who is about to retire from Reading, is one of those scientists who mixes good sound basic understanding of his field with wit and a bit of deliberate eccentricity. He has a capacity for breaking through the trappings that often adorn scientific and technical concepts and in getting to the heart of the matter and sometimes revealing basic absurdities. Gordon has shared much of his insight in two delightful books, *Structures, or Why Things Don't Fall Down*, and *The New Science of Strong Materials, or Why You Don't Fall Through the Floor* (Harmondsworth, UK, Penguin Books, Ltd., 1978) which are not only quite readable and very instructive but also highly amusing.

Jeronimides and others have shown that the structure of wood consists of long parallel rectangular tubes cemented together by a relatively weak noncellulosic binder. The walls of the cells consist of layers of cellulose fibers which wind in a helical fashion around the tubular cell, making an angle of 6-30° to the longitudinal direction of the cell. A crack propagating through the tubular structure (across the grains) is blunted first by the bonding between the tubular cells (the Cook-Gordon mechanisms) and then tensile forces on the individual tubes cause the cellulose fibrils to unwind from their helical position. It is this latter deformation mechanism, which enables the cells to elongate by up to 20% under tensile loads, that is responsible for the great toughness of wood.

Jeronimidis has been able to introduce this unwinding deformation mechanism into glass-fiber organic-matrix composites. He prepared thin tubes of glass fiber by winding the fiber around a nylon core.

The glass wrapping was coated with an epoxy resin which was allowed to set, and the nylon filament was withdrawn. He then packed these tubes of glass fiber into an epoxy matrix to form a composite which had very high impact strength and through which he could drive nails without extensive cracking. This material would seem to have commercial value and some interest has been shown by an American company.

Gordon is currently interested in the mechanical properties of biological tissue such as skin or the walls of blood vessels. These materials are also composites, being composed of randomly oriented collagen fibers in a low modulus elastin matrix. He is specifically interested in cerebral aneurisms which occur when the walls of blood vessels lose their resistance to tear. More precisely, the vessel wall material develops a rubberlike elasticity so that the blood pressure causes a bulge to form until the material reaches its breaking strength and the artery bursts. Rubber and biological tissue have very different stress/strain curves. A typical rubber shows a knee at low strain levels whereas tissue, because of the low modulus of the elastin matrix, undergoes considerable strain at very modest stresses before the modulus begins to increase sharply. It is this "flabby" characteristic of animal tissue which gives it resistance to cracking or tearing and prevents the propagation of tears or cuts when they do form. The reason for resistance to tear propagation in tissue is that although the stress at the tear tip may be quite high, the stress in surrounding tissue is low, and so is the strain energy density to propagate the tear. Gordon's interests are in the micromorphology of blood-vessel wall tissue and in learning how this morphology changes to allow aneurisms.

Nature has a great deal to teach about materials—especially composites which abound in the animal and plant kingdoms—and about structural design. However, even a casual reading of the book by Wainwright, et al. reveals how really ignorant we are about natural materials and the structures of the simplest of organisms. (Willard D. Bascom)

#### POLYMER TECHNOLOGY IN MANCHESTER

John Dalton arrived in Manchester, England, in 1793 to become professor of mathematics and philosophy at New College, just as the industrial age was flowering. Steam engines had been introduced into cotton weaving just 4 years earlier. Dalton was a meticulous observer and recorder of natural phenomena and like his scientific

contemporaries—all members of the Manchester Literary and Philosophical Society—kept his distance from the practical engineering that was shaping industrial growth. In 1799 New College moved to new location and became the College of Manchester at Oxford. Dalton, however, remained in Manchester and became a public teacher of mathematics and natural phenomena. His lectures were delivered to the idle rich; those shaping the Industrial Revolution had little need for his mathematical philosophy. John Dalton was bystander to the Industrial Revolution. It is ironic that, today, heavily-industrialized Manchester has taken Dalton as something of a patron saint. At Manchester Polytechnic, for instance, there is a large bronze profile of Dalton at the entrance to the John Dalton Faculty of Technology.

Manchester Polytechnic (MP) is one of the largest and most prestigious of the UK polytechnics, and the Polymer Technology Department (part of the John Dalton Faculty) is no small contributor to the financial strength and reputation of MP. The department head is Prof. V.G. Bashford, who came to the polytechnic 14 years ago, when the school was known as the Newton Heath Technical College, to head the Rubber Technology Department. In 1964 Newton Heath became part of the John Dalton College of Technology which was consolidated into Manchester Polytechnic in 1970.

When Bashford took over the department, it had no research effort and its curriculum was a fragmented collection of courses in rubber and plastics technology. Today there is a staff of 23 professionals and a solid curriculum in basic polymer science and technology. Until recently, the major research effort was devoted to the ablation of filled polymers. Although some of that work continues, the present research emphasis is largely on polymer fracture and dental prosthesis materials with some small efforts in coatings and textiles.

Work on polymer fracture began when Dr. Philip Marshall came to the Polymer Technology Department from Imperial College (Univ. of London) where he had been a student and later a co-worker of Prof. Gordon Williams. Marshall brought to MP a solid reputation in polymer mechanics and an awareness that industrial users of plastics have a lot of problems, many of which can be related to the fact that they do not understand how plastics fail. In Marshall's opinion, the situation is aggravated by the fact that most of the standard tests (in both the UK and the US) do not address the actual failure mechanisms. Too often, qualifying tests are done at temperatures, strain rates,

and environments that bear no relation to what the material experiences in application. Marshall has gone to industry and government (principally the Polymer Engineering Directorate [PED], ESN 33-5:189 [1979]) and said, "We will find the Achilles' heel, you design around it."

Some of the specific problems Marshall and his group are working on include polyvinylchloride (PVC) and polyethylene (PE) pipe, polycarbonate (PC) crash helmets, and glass-reinforced plastics (GRP) composites. The PVC work centers on developing meaningful fracture test methods with emphasis on how water and organic liquids affect fracture. Marshall thinks that present industrial performance standards are much too severe and that PVC pipe is generally overdesigned.

The work on PE concerns the failure of medium-density PE gas pipe. The standard British Gas Institute test is to apply internal hydrostatic pressure at 80°C until the pipe segment bursts. Failure appears to involve brittle cracking, but Marshall thinks that this is because of the particular temperature and strain rate of the test and that possibly water is assisting crack initiation. His data suggest that in practice failure is often ductile yielding. Consequently, one of the major efforts of the Manchester Poly group is to determine the failure mode (ductile or brittle) over a wide range of test conditions including wet environments.

In an investigation of the brittle fracture of PC air-filter enclosures, Marshall discovered that the polymer was degrading hydrolytically and that the degradation was causing embrittlement. He is now determining the mechanism and kinetics of this hydrolysis which he feels is critical to understanding failure.

Motorcycle helmets made from PC have been found to shatter on impact, and in some cases have contributed to the severity of accidents. Although PC is generally considered a tough polymer, Marshall is convinced that in this particular application the material is notch-sensitive. He is presently gathering evidence to support that contention.

One of the first landmarks one sees on driving into Manchester at night is the floodlit sign, UMIST, on the top of a prominent multistory building. The building is the newest in a cluster of buildings that make up the University of Manchester Institute of Science and Technology (UMIST) in the heart of the city. I visited the Department of Polymer and Fiber Science which was headed by Prof. I.R.G. Treloar, until his recent retirement. Treloar was world renowned for his work in rubber elasticity. The present

head of the department is Prof. R.H. Peters, who was out of town at the time of my visit. My host in his absence was Dr. T.P. Nevell. Under Treloar, there was a strong emphasis on rubber elasticity in the department's polymer physics effort. Under Peters, the polymer physics activity is directed to investigating the physical and mechanical properties of composites. The work is mainly on the visco-elasticity and fracture of polymers containing particulate or short fiber fillers. These investigations are closely tied to commercial materials such as glass-reinforced nylon. The principal investigators in this work are Drs. J.P. Barry, J.L. Stanford, and E.F.T. White, who also do some work in cooperation with Dr. C.A. Buckley of the UMIST Department of Textile Technology. The emphasis of the work of this group thus far has been on the viscoelastic (stress relaxation) behavior of the composites. They find that moisture has a very strong effect on stress relaxation which is not surprising in view of the moisture sensitivity of nylon. These moisture effects are very much influenced by whether or not the filler material has been given a surface treatment (silane or silicate coupling agents). Barry and his associates are seeing similar moisture effects on composites fabricated with polypropylene or polyurethane as the polymer matrix.

White talked very enthusiastically about a new nonflammable fabric that had been developed at UMIST and which is now on the verge of commercial production. He was reluctant to disclose too many details about how this fabric is produced but it is evidently formed from rayon cloth that has been partially carbonized; the final product is jet black. According to White, the treatment is relatively rapid and inexpensive. White placed a piece of rayon cloth in the flame of a Bunsen burner. The cloth did not burn or give off smoke, and it took more than six minutes before there was a full breakdown of the fibers. He claims that the material retains reasonable strength even after three minutes of direct contact with a flame. The material appears to have potential use as a flame barrier. Also, it is very flexible and can be thrown over a petroleum fire as a fire blanket. White has established that the decomposition products have low toxicity and that the fabric can be made from cloth having various types of weaves, usually with less than 50% loss of the original tensile strength. The major problem is that the fibers have poor abrasion resistance and cannot be woven directly into cloth. Although the product is on the verge of commercial production,

development work continues at UMIST for the purpose of improving the abrasion resistance of the fabric, increasing retention of the original strength of the untreated fiber, and finding ways of molding the fabric into shapes for fireproof enclosures.

The department's work in polymer chemistry is largely focused on the relation between molecular structure and thermal degradation, and on polymer networks. The department has a long history of work on polymer thermodegradation dating back to the early 1970s when Bashford at Manchester Poly and Dr. R.H. Still at UMIST worked on the ablative insulation, smoke emission, and flash characteristics of fiber-reinforced composites used in rocket motors. Since that time, Still has synthesized and characterized the stability of a number of polymers including substituted polystyrenes and polyphenylene sulfides (PPS). In the PPS work, Still has determined the synthesis parameters of a wide range of poly(arylene sulfides). These polymers have very complex crystalline morphologies and appear to have potential as commercial, structural plastics.

The department's involvement in polymer networks—both theoretical and experimental—is rapidly expanding, largely through the guidance of Dr. R.F.T. Stepto. I met Stepto at the 9th Europhysics Conference on Macromolecules (ESN 33-11:400 [1979]) where he described his work on polyester and polyurethane networks. This work can be viewed as an extension of Treloar's studies, but with more emphasis on chemistry and less on mechanics. A polymer network group has been formed at UMIST which includes staff from the Department of Mathematics as well as from the Department of Polymer and Fiber Science. Current activities include theoretical studies of ring formation, rheology of gelling systems, network formation (gelation) in the presence of filler, and the effect of network structure on the dynamic mechanical properties of cured polymers. Much of this work is aimed at commercial injection molding, especially the fast reactions that occur in reaction-reinforced injection molding (RRIM).

Stepto showed me a videotape he and his colleagues had developed that illustrates the conformational fluctuations of macromolecules adsorbed by solid surfaces (they used Monte Carlo statistics). They also have a videotape illustrating the dynamics of polymer chain configurations. Both films have been expertly crafted and would be useful for undergraduate courses in polymer science. Unfortunately, the tapes were made for British television and will not play on US television receivers. Stepto also has a movie film which can be purchased.

The department has a strong involvement in polymer process engineering partly because of the presence of and easy access to the engineering department at UMIST and also because of a desire to keep a close connection between their polymer physics and chemistry research and industrial needs. They have recently completed an extensive study with the Department of Mechanical Engineering on filament-wound fiber-reinforced composites and on polymer extrusion. A new program on RRIM was scheduled to begin in late 1980 with funding from the Wolfson Foundation. The work will be done by Stanford and Still, four graduate and postgraduate students, and a staff engineer; the group has been designated the Wolfson Polymer Research Unit. Although the emphasis will be on RRIM, the guiding objective of the program is energy conservation in polymer processing and fabrication. The tasks include the synthesis of new RRIM polymers based on non-petroleum feedstocks. Also, the researchers hope to develop resins with lower viscosities and lower cure temperatures and pressures than the current RRIM resins. They plan to design a small RRIM machine; if it is successful, the UMIST group hopes to introduce the machine into UK industry, which generally lags behind the US in this technology.

UMIST has obtained funding from the UK automobile industry to purchase large commercial RRIM equipment. The automobile manufacturers have a special interest in RRIM because of its high production rate compared to that of other polymer molding techniques. Stanford and his co-workers will use this machine to study the rheological behavior of polyol slurries at high strain rates.

The Wolfson Foundation's support of research and development on RRIM at UMIST is only part of a concerted effort throughout the UK to catch up with the US in this technology. The PED is funding research in industry, and at the University of Liverpool and the University of Bradford on the type of fiber that can be used for reinforcement and how the fiber affects the properties of the molded product. The researchers at Bradford are making parts for mechanical characterization, they are developing a component for British Leyland, and they are looking into ways of computer-controlling RRIM equipment.

In a recent reorganization of polymer and textile research at UMIST, the processing aspects of textiles were transferred to the Department of Textile Technology and the textile chemistry work was assigned to the Department of Polymers and Fiber Science. The people most

active in textile chemistry are Drs. A. Johnson and W.C. Ingamells. They are primarily concerned with finding ways of reducing the energy consumption during the dyeing of the fabrics. Two ways in which this can be done are to lower the bath temperature and use aqueous solvent systems--usually water/organic solvent mixtures. For synthetic polymeric fibers, the bath temperature can be reduced if the glass transition temperature ( $T_g$ ) of the polymer during the dyeing operation can be reduced. Near  $T_g$  the greater free volume of the polymer facilitates dye absorption. The  $T_g$  can be reduced by using plasticizers that are sufficiently volatile to be removed after the dyeing operation. Johnson and Ingamells have been investigating the use of various plasticizers and dyes for treating polyacrylonitriles, PE, and polypropylene fibers. Thus far, they have been able to develop a correlation between dye adsorption and the solubility parameters of the dye and fiber.

During the reorganization of research efforts mentioned earlier, the work in paper science remained in the polymer department; this is the reason for fiber science in the department's name. The paper group is really a department within a department considering the size and depth of this operation. It offers MSc and PhD degrees in paper science which are highly regarded by the industry in England and abroad. The group is headed by Prof. H.V. Kropholler, has a staff of six, and is well equipped for both teaching and research. The research ranges from the automation and quality control of paper making to cellulose chemistry. One of the larger efforts involves the use of noncellulose fillers in paper to obtain special properties, e.g., high temperature strength, stiffness, water resistance, etc.

Dr. L.A. Kirk is investigating the mechanisms involved as paper dries at the end of the papermaking process. Getting rid of the last one percent of water is a rather energy-intensive operation and Kirk hopes to find some means of reducing the temperature and time required for the final drying. This residual water is tenaciously held by the fiber and is referred to as "bound" water. Kirk plans to use radio tracer techniques to determine how the water is adsorbed and how it diffuses out of the paper. He also described the research on fiber-fiber interaction. Specifically, the researchers are trying to find the key parameters that determine

fiber adhesion, e.g., H-bonding, fiber size, shape, and flexibility. They also want to know whether these interactions cause the fibers to damage (induce flaws) each other.

All of the work that I heard about at MP and UMIST was closely tied to industrial needs and problems. But there is no cause for worry, John Dalton. The research is concerned with basic polymer science and engineering and is strongly targeted to help the UK industry at a time when that help is sorely needed. The contribution to "natural philosophy" is nonetheless formidable. (Willard D. Bascom)

## MEDICAL PHYSICS

### CURRENT LEVELS OF GONADAL IRRADIATION FROM X-RAY EXAMINATIONS IN GREAT BRITAIN

It was some 20 years ago that Great Britain had last assessed the doses received by patients from routine diagnostic X-ray examinations. A committee chaired by Lord Adrian, (Professor Emeritus of Physiology, Cambridge Univ.) made such a survey in 1958. Because considerable changes in the practice of radiology in the UK (and in other developed countries) had taken place since that last survey was made, the National Radiological Protection Board (NRPB) decided to update the information available to it by conducting another survey. A selection of hospitals in England, Scotland and Wales was made that were suitably representative of radiological practice in Great Britain.

The purpose of the survey was to determine trends in the pattern of use of diagnostic radiological procedures, and also to permit a remeasurement of the genetically significant dose (GSD), defined as the dose which, if delivered to each person in a population, would have the same genetic consequences as the actual pattern of gonadal radiation dose distribution. It can be argued that the absence of any direct benefit to the progeny of patients receiving medical X-ray exposure imposes an obligation on all concerned to minimize genetic risks. Diagnostic radiological procedures are important in this context, since a large fraction of the fertile population receives X-ray examinations each year.

This ESN is based on a report published by the NRPB in July 1980: NRPB-R105, "Current Levels of Gonadal Irradiation from a Selection of Routine Diagnostic X-ray Examinations in Great Britain," Wall, B.F., Fisher, E.S., Shrimpton, P.C., Rac, S., Harwell, Didcot, Oxon OX11 0RQ. (See ESN 34-12:566 [1980]).

Computing the GSD requires a measurement of the gonadal doses delivered by only those examinations which make significant contributions to the GSD. Generally these are examinations in which the ovaries and testes are in the X-ray beam, or close to the border of the beam. The 1958 Adrian survey showed that just 9 types of examination accounted for 95% of the GSD. See Table 1.

TABLE 1

Contributions to the GSD by Type of Examination in the 1958 Adrian Survey

Examination Type	Contribution as % of Total GSD
Fetal Maturity	26
Pelvis, lumbar spine, LSJ*	24
Intravenous pyelography	12
Upper femur, hip	11
Pelvimetry	8.6
Abdomen	4.5
Barium meal	3.8
Chest, heart, lung	3.6
Barium Enema	1.2
Total	95.

\*LSJ = lumbo-sacral joint

The advent of ultrasound as a diagnostic tool for obstetric examinations, and the increased concern in recent years about the risk of exposing the developing fetus to ionizing radiation may have reduced the contribution of obstetric abdominal examinations. However, it was thought prudent to include this kind of examination in the survey. The examination category of pelvis, lumbar spine, and LSJ was considered to be important enough to expand into three separate categories: pelvis alone; lumbar spine and lumbo-sacral joint; and pelvis, lumbar spine, and lumbo-sacral joint combined. Radiologists also requested the addition of cystography and lumbar myelography as possible contributors to the GSD. Altogether, this makes 13 examination types selected for the current survey, which were thought likely to contribute 95% or more to the GSD.

Measurements of patient dose were made at 21 hospitals on a total of 4,565 patients covering the 13 selected types of diagnostic X-ray examination.

A dosimetry system was developed that would be relatively simple, since busy hospital staff, after brief instruction, would be carrying out the actual measurements. Small adhesive sachets of lithium borate thermoluminescent powder were attached to the patients to measure directly the skin dose received during the X-ray examination. For male patients the sachets

were positioned on the inside of the thigh, level with the testes. For female patients the entrance skin dose at the level of the ovaries was measured by placing the sachets on the lower abdomen at the level of the anterior-superior iliac spines. Skin-to-ovary dose conversion factors were worked out based on measurements with a suitable phantom. After the examination was completed, the sachet was removed from the patient and was attached to a form on which relevant details concerning the patient had been entered.

Table 2 lists the results of the mean values of the gonadal dose for the 8 most significant types of examinations. The units employed are the so-called SI units. For absorbed dose the new unit is named the gray (Gy), and it is related to the old unit, the rad, as follows:

$$1 \text{ Gy} = 100 \text{ rad} \\ 0.01 \text{ Gy} = 1.0 \text{ cGy} = 1 \text{ rad}$$

TABLE 2

Mean Values of Gonadal Dose by Examination Type and by Sex for All Age Groups in units of (cGy)

Examination Type	Male	Female
Upper femur, hip	0.638	0.075
Pelvis	0.553	0.164
Cystography	0.450	0.630
Intravenous pyelography	0.387	0.324
Barium enema	0.330	1.59
General abdomen	0.151	0.080
Lumbar myelography	0.069	0.839
Lumbar spine, LSJ	0.058	0.380

The relative importance of the different examination types for males and females is shown in Table 2. Thus fluoroscopic examination of the lower abdomen for women (Barium enema) appears as the maximum for the female listings.

Gonadal doses associated with chest examinations are less than those listed by a couple of orders of magnitude (about 20 Gy for both sexes).

Table 3 gives a comparison of the mean gonadal doses obtained in the current survey with those obtained by the Adrian Committee 20 years ago. Only the mean doses for patients over 15 years old are included for the current survey, as the Adrian report does not quote values averaged over all age groups. For this reason the values listed for the current survey differ somewhat from the data of Table 2.

TABLE 3

Mean Gonadal Doses per Examination in Current Measurements and in the Adrian Survey (1950s) (Units are in cGy=rad)

Examination	Males		Females	
	Current	Adrian	Current	Adrian
Upper femur, hip	0.840	1.12	0.096	0.117
Pelvis, lumbar spine, LSJ*	0.339	0.387	0.376	0.405
General abdomen	0.164	0.103	0.084	0.212
Fetal maturity	0.315	0.723	0.281	0.367
Pelvimetry	0.223	0.885	0.341	0.745
Intravenous pyelography (IVP)	0.434	0.804	0.358	0.637
Barium enema	0.335	0.146	1.60	0.464
Barium meal	0.030	0.043	0.360	0.339
Cystography	1.83	0.964	1.42	1.28

Some of the examinations show a decrease and some an increase in the dose delivered to the gonads. However, except for pelvimetry, IVP and the barium enema, the differences are not statistically significant. The barium enema examinations produced doses differing by ratios of 2.3 for males and by 3.4 for females, the current values being higher in both instances. The authors attribute this increase to the larger number of films taken currently for this examination type.

There is a general improvement in current practice because of better collimation, especially in taking full-size chest views. In the Adrian survey 53% of female patients receiving a full-size chest X-ray had their ovaries in the beam. For males the comparable percentage in the Adrian survey was 16%.

The authors draw several main conclusions from the current survey. First, there is no indication of a marked increase or decrease in adult gonadal doses delivered per examination since the late 1950s. Secondly, they find that the variation in gonadal dose for a given examination type both within the same hospital and between hospitals is very large. The point here is that it would be difficult to separate "good" hospitals from "bad" ones. The exception to this is the IVP (intravenous pyelogram) examination for females for which the mean of the 3 hospitals with the highest dose was 3.5 times the mean of the 5 hospitals with the lowest dose.

There have been a number of changes in technique for diagnostic radiology which might be expected to lead to lower doses for the patient. These include the general use of non-screen film, and the recent availability of very sensitive rare-earth screens, not available during the time of the Adrian survey. However, a check showed that only 5 out of the 21

hospitals in the survey were using rare-earth screens, and then mostly for obstetric examinations. The usual reasons given for not using rare-earth screens were their high cost and poorer definition due to quantum mottle. Of the hospitals where obstetric examinations were performed some 70% did use rare-earth screens, and indeed fetal and maternal gonad doses dropped as a consequence. The drop in dose for pelvimetry is associated with current stringent restrictions on beam size as well as the use of faster screens. The differences shown in Table 3 for the IVP examination are probably due to the use of faster film/screen combinations.

The authors make the point that diagnostic radiology probably accounts for 90% of the total GSD to the population of the UK from all man-made sources of radiation. Thus even a reduction as small as 10% in diagnostic exposures would be a significant improvement. The great variability observed in individual gonadal doses suggests that some patients are receiving unnecessarily high doses. By simply improving radiological techniques, a substantial reduction in the collective gonadal dose could be achieved without reducing medical benefits. (See ESN 34-12:566 [1980] for some evidence of wide variability; this was also shown in an Italian survey discussed in ESN 34-9:443 [1980]).

A companion article in this issue presents the estimation of GSD from diagnostic radiology in Great Britain in 1977. (Moses A. Greenfield)

#### GENETICALLY SIGNIFICANT DOSE FROM DIAGNOSTIC RADIOLOGY IN GREAT BRITAIN IN 1977

Medical irradiation is the largest man-made contributor to the population dose and results in the highest doses to individuals and to individual organs. For the individual patient the somatic hazards involved are balanced against the benefits received in terms of needed diagnostic information. The genetic detriment of the radiation exposures is not offset in any direct manner. One measure of genetic effects is the genetically significant dose (GSD), defined as that dose which, if given to every member of a population, would produce the same total genetic injury as the actual doses received by the various individuals. Thus the GSD represents a national average dose.

A survey to determine the GSD in Great Britain was made in the late 1950s by a committee chaired by Lord Adrian, Professor Emeritus of Physiology, Cambridge University. One of the committee's recom-

mendations was to keep the situation under continuing review. The Council of the European Communities has also recommended that its member states consider and determine the radiation-induced genetic burden on society. It was for these reasons that the National Radiological Protection Board (NRPB) of the UK decided to update the findings of the Adrian committee. The results of the NRPB survey were published recently (September 1980) as report NRPB-R106, "The Genetically Significant Dose from Diagnostic Radiology in Great Britain in 1977," by S.C. Darby, G.M. Kendall, S. Rae, and B.F. Wall.

The survey was undertaken in cooperation with the health departments of England, Scotland, and Wales. Their report estimates the annual GSD to the population from diagnostic radiology. This is done by combining information on the frequency of certain types of examination procedures in diagnostic radiology with the magnitude of the gonadal doses associated with these procedures (see ESN 34-12:566 [1980] and the article preceding this one) together with information on the child expectancy of the various age groups that were examined. From the definition given above for GSD one may write a general expression for it in terms of the parameters mentioned in the previous paragraph as follows:

$$GSD = \frac{\sum_k \sum_l N_{kl} P_{kl} D_{kl}}{\sum_k N_k P_k}$$

$N_{kl}$  is the number of individuals in the  $k$ th age-sex group who received an examination procedure of type  $l$  during the year.

$P_{kl}$  is the child expectancy of an individual in the  $k$ th age-sex group receiving an examination procedure of type  $l$ .

$D_{kl}$  is the mean gonadal dose for the  $k$ th age-sex group with procedure  $l$ .

$N_k$  is the number of individuals in the  $k$ th age-sex group in the population.

$P_k$  is the child expectancy of individuals in the  $k$ th age-sex group.

Another way to write the above equation for GSD which the authors found convenient for their calculations is the following:

$$GSD = \frac{\sum_k E_k D_k}{\sum_k N_k P_k}$$

with  $E_k$  the total number of children expected by those in age-sex group  $k$  receiving examination procedure type  $l$  in a year.

For the purposes of the survey an appropriately designed selection process resulted in a sample which included 79 hospitals in England, 28 in Scotland and 5 in Wales. The number of examination types included in the survey was 27, and a list is provided in Table 1.

TABLE 1

Abdomen
Abdomen, obstetric and pregnant
Angiography, abdomen
Angiography, head
Angiography, peripheral
Ankle and foot, Arm and hand
Ba meal
Ba enema
Ba swallow
Cardiac angiography
Computerized tomography, head
Cholangiography
Chest
Cystography
Dental
Dorsal Spine
Femur, upper third and hip
Femur, middle and lower third
Head and neck
Hysterosalpingography
Urography
Lumbosacral area
Lumbar myelography
Mammography
Pelvis
Lymphangiography

The frequency survey produced an estimate of 21.3 million diagnostic radiological examinations performed in Great Britain in 1977 in NHS hospitals. This is a rate of 393 examinations per thousand of population, an increase of 2% per annum since 1957. The GSD depends on the way these frequencies are distributed amongst the various age groups. Table 2 is a listing of the most important examination types, accounting for 90% or more of the totals, by age and sex.

Table 2 shows that in absolute numbers older women account for the largest number of examinations. When the relative populations of the various age groups are taken into account, the rate of examination per thousand is about twice as great in the 50+ age group as it is in the 0-14 age group, for both sexes.

TABLE 2

Estimated Numbers, in Thousands, of Radiological Examinations in Great Britain in 1977 by Examination Type\* and Age for Both Sexes

Type	0-14	15-49	50+	0-14	15-49	50+	Total
Abdomen	50.6	194.8	203.4	45	148	135	897
Ankle, foot	199.2	485.4	637.5	297	313	340	2,770
Arm, hand	335.3	303.8	364.2	378	732	212	2,410
Ba m.	-	104.3	164.8	-	128	127	-
Ba en.	-	-	112.3	-	-	-	-
Chest	213.7	1371.3	2031.6	307	1378	2225	7,530
Cholangi	-	134.2	146.2	-	-	-	410
Dental	57.3	107.4	-	52	90	-	-
Femur, upper	37.8	-	224.5	-	81	101	515
Femur, lower	32.7	-	141.9	-	-	-	-
Head, Neck	187.5	452.6	451.8	307	548	334	2,280
Uroq	30.4	191.2	-	-	84	144	450
Lumbosac	-	236.5	272.5	41	222	187	980
Pelvis	76.4	125.8	307.6	55	138	150	850
Total	1291.	4009.	5418.	1624	4620	4375	21,300

\*The examination types are abbreviations of those listed on Table 1.

The estimated gonadal doses produced by the various types of examinations are listed in Table 3 by age group and by sex, in SI units of mGy = 0.1 rad. For reasons of clarity values are listed only for those types which ultimately contribute to the GSD.

TABLE 3

Estimated Gonadal Doses by Examination Type, Age and Sex

Type*	Female			Male		
	0-14	15-49	50+	0-14	15-49	50+
Abdomen	0.51	0.79	0.85	0.66	1.58	1.67
Abdomen ob	0	3.14	0	-	-	-
Angio per	10.0	10.0	10.0	30.9	30.0	30.0
Ankle, foot	0.03	3.03	0.03	0.03	0.03	0.03
Arm, hand	0.02	0.02	0.02	0.04	0.04	0.04
Ba m.	0.17	1.54	5.01	0.12	0.27	0.32
Ba en.	4.54	14.3	16.6	1.38	2.50	3.57
Chest	0.80	0.80	0.80	0.07	0.07	0.07
Cholang	0.80	0.80	0.80	0.07	0.07	0.07
Cysto	4.29	14.0	14.0	2.53	18.0	18.0
Dental	0.70	0.10	0.10	0.60	0.06	0.06
Dors sp	0.16	0.96	1.03	1.62	6.13	10.5
Femur, upper	0.05	0.07	0.07	0.25	1.20	1.20
Femur, lower	0.10	0.01	0.01	0.01	0.005	0.005
Head, Neck	0	5.00	5.00	-	-	-
Hystero	1.64	3.11	4.02	0.60	3.57	4.67
Uroq	1.94	3.90	3.84	0.42	0.64	0.52
Lumbosac	8.39	8.39	8.39	0.70	0.70	0.70
Myelo	0.33	1.16	2.21	1.46	2.94	7.62
Pelvis	5.00	5.00	5.00	10.0	10.0	10.0
Lymphang	5.00	5.00	5.00	10.0	10.0	10.0

\*The examination types are abbreviations of those listed in Table 1.

The last component required for computation of the GSD is the estimation of child expectancy by age and by sex. These data are listed in Table 4, based on a report by F. Taylor (1980, NRPB-M49, Harwell, National Radiological Protection Board).

TABLE 4

Child Expectancy by Age and Sex

Age interval	Female	Male
0-1	1.86	1.82
2-4	1.89	1.86
5-9	1.89	1.86
10-14	1.90	1.87
15-19	1.80	1.84
20-24	1.39	1.62
25-29	0.76	1.10
30-39	0.19	0.39
40-49	0.01	0.05
50-59	-	0.01
60+	-	-

Combining the data presented above with 1977 populations for England, Scotland, and Wales, the authors estimated the contribution to the GSD by examination type, by age groups, and by sex. These data are presented in Table 5. Listings of examination types are included only when a contribution of at least 1  $\mu\text{Gy}$  is made to the GSD. Note that 1  $\mu\text{Gy}$  = 0.1 millirad. The sums of the components do not always equal the "total" value because of rounding off errors.

TABLE 5

Estimated Contributions to the GSD  
by the More Important Examination  
Types in  $\mu\text{Gy}$ \*

Type	Female		Male		Fetal	Total
	0-14	15-49	0-14	15-49		
Abdomen	1	2	1	4	0	9
Obstetric						
Abdomen	0	2	0	0	4	6
Ba Enema	0	8	0	1	1	9
Cystography	2	2	1	5	0	12
Upper Femur						
& Hip	0	0	2	12	0	15
Urography	2	5	1	4	1	13
Pelvis &						
lumbo sacral	3	12	4	9	1	30
area						
Other	4	6	3	7	2	19
Totals	12	37	12	42	9	113

\*by Age and Sex

As Table 5 indicates, the GSD from diagnostic radiology in NHS hospitals in Great Britain in 1977 is estimated to be 113  $\mu\text{Gy}$  (11.3 millirad). The standard error is estimated to be about 12  $\mu\text{Gy}$  or 10%. If hospitals other than NHS are included, the GSD is revised to 118  $\mu\text{Gy}$  (11.8 millirad). The estimate

of 118  $\mu\text{Gy}$  may be compared with 141  $\mu\text{Gy}$  from the 1957 Adrian survey. However, the difference is somewhat less than twice the standard error and may not be indicative of a decrease. As Table 5 shows, the major contributors to the GSD are Pelvis and Lumbo-sacral area; Femur, upper third and hip; Cystography; Urography; Barium enema. Taken together these six types of examination account for 70% of the GSD. These contributions are roughly similar to the findings of the 1957 survey with the exception of obstetric abdomen examinations. (See Table 6.) These dropped from a 1957 value of 45 to 6  $\mu\text{Gy}$  in 1977. The drop was due both to a diminution in frequency of this type of examination and also in the fetal dose. The GSD from cystography has increased compared to 1957 because of an increase in frequency of examination.

TABLE 6

Genetically Significant Dose from Selected  
Diagnostic Examinations in Great Britain  
in 1957 and in 1977 in NHS Hospitals

Type*	1957				1977			
	Female	Male	Fetal	Tot.	Female	Male	Fetal	Tot.
Abdomen	3	2	1	6	4	6	0	9
Abdomen								
ob	17	-	29	45	2	-	4	6
Ba en.	1	0	0	2	8	1	1	9
Cysto	0	0	0	1	5	6	0	12
Femur,								
upper								
& hip	1	13	0	15	1	15	0	15
Urog	7	10	1	17	7	5	1	13
Pelvis &								
Lumbosac	12	17	2	31	15	13	1	30
Other	9	6	1	15	7	9	2	19
Total	50	48	34	132	49	55	9	113

\*(The examination types are abbreviations of those listed on Table 1.)

Examinations of children contribute one third as much GSD as that received by adults. Lower examination frequencies and lower gonadal dose per examination both contribute to this effect.

It should be noted that over the past 20 years the GSD has remained virtually the same despite an increase of about 50% in the frequency of radiological examinations per thousand. Two factors that contribute to this situation are the reduction in doses generally per examination plus the marked reduction in diagnostic obstetrical examinations. The latter reflects the increased awareness of the radiosensitivity of the fetus, and also the general availability of ultrasound techniques.

A comparison of the GSD in Great Britain with some other countries is given in Table 7.

TABLE 7

Year	Country	GSD( $\mu$ Gy)	Population in millions	Annual # Exams per Thousand
1977	Great Britain	120	55	440
1974	Japan	170	108	810
1970	USA	200	195	646
1972	Netherlands	280	12.6	1140
1974	Italy	300	55	438
1974-6	Sweden	460	8.1	650

The authors conclude that the situation in Great Britain is satisfactory, especially, as pointed out earlier, since the GSD has not increased despite increases in the number of examinations. They do make a plea for greater and more consistent use of gonad shielding which is simple and inexpensive. It appears from their survey that such shielding is being used more effectively with children. In fact they state that equally effective use of gonad shielding for adults would reduce the GSD by as much as 50%. The GSD is small compared to the levels of normal background radiation and, in fact, the authors note that it is of the same magnitude as the differences in the levels of normal background radiation received by people living in different parts of Great Britain. Thus the potential hazard associated with the magnitude of the GSD seems small in comparison with the benefits received as a consequence of diagnostic radiological examinations. (Moses A. Greenfield)

## MEDICAL SCIENCES

### THE BRITISH PHYSIOLOGICAL SOCIETY MEETING

The annual meeting of the British Physiological Society took place at Cambridge University, Cambridge, England, on 10-11 July 1980. The format of the meeting was in a style established by over 104 years of tradition; this included short presented papers and laboratory demonstrations. Tea was served in the teaching laboratories at 4 p.m. each day to allow participants to discuss the papers presented. The Physiological Society is one of the few traditional scientific groups that debate the merits of papers at the time of presentation and actually vote on whether to accept the papers for publication in the *British*

*Journal of Physiology*. The ceremonial dinner for the Society was held in the impressive dining hall of Trinity College and port and cheese were served with the introduction of the new president, Dr. Richard D. Keynes, Cambridge University.

Ten laboratory demonstrations were set up in the teaching laboratories, and participants could view experiments in progress and in several cases participate in the manual operation of specialized equipment. Dr. T.J. Rink and Dr. R.Y. Tsien (Physiological Lab., Cambridge Univ.) demonstrated a simple method for grinding and beveling the tips of calcium sensitive microelectrodes for greater ease of penetration into cells and the achievement of a minimum electrode tin diameter. Dr. V.L. Lew and Dr. Carol A. Seymour (Cambridge Univ.) presented a videotape of spontaneous inside-out vesiculation of lysed human red cells at 37°C. Several other demonstrations dealt with new electrophysiological instruments and biochemical detection methods.

The program of 100 short papers was diverse and represented many aspects of modern physiology. Invited participants were from the UK, Ireland, FRG, US, Canada, Australia, France, Italy, Switzerland, Brazil, and Japan.

Dr. W.R. Adey (Veterans Hospital, Loma Linda, CA) presented a paper which demonstrated increased calcium efflux from cerebral tissue exposed to weak microwave fields. Calcium efflux increased by as much as 15% in chick cerebral hemispheres in fields of 0.1-1.0 mW/cm<sup>2</sup>. Similar results were reported for rat brain synaptosomes and cat cortex slices. These responses were proposed to be consistent with cooperative organization of membrane surface glycoproteins in the binding and release of calcium as first steps in the transduction of weak electrochemical stimuli.

Dr. T. Bennet and associates (Univ. of Nottingham, UK) demonstrated the influence of beta-adrenoreceptor antagonists on thermoregulation during insulin-induced hypoglycemia. With insulin-induced low-blood-sugar levels, heat production by the body increases, but body core temperature and skin temperature fall due to extensive vasodilation. This work may lead to a new understanding of human thermoregulation in warm environments.

Investigators from the University of Sao Paulo, Brazil, reported that injections of hyperosmotic solutions could greatly increase the survival of dogs, cats, rats, and humans suffering from severe hemorrhagic shock. Dr. O.U. Lopes, Dr. Vera Pontieri, Dr. M. Rocha e Silva and Dr. I.T. Velasco have demonstrated that the vagus nerve is somehow involved

in the mechanism of response. Discussions from the floor suggested a pituitary feedback loop. Such experiments suggest that the infusion of normal saline to restore blood volume may not be sufficient to restore health. This work has far-reaching implications for battlefield and field-hospital treatment of hemorrhagic shock victims.

Dr. P.T. Beall (Baylor Univ.), Dr. M.M. Cassidy (George Washington Univ.) and Dr. M. Dinno (Virginia Technical Univ.) presented experiments sponsored by the Office of Naval Research, Biophysics Program. A drug, Cytochalasin B, which depolymerizes fibrous actin polymers in the cytoplasm of transporting cells can greatly affect water and salt movement across the frog stomach and rat intestine walls. The paper, which was accepted for publication in the *British Journal of Physiology*, adds a new circuit to the classical electrical model of membrane transport to account for the role of cytoplasmic resistance in transport. Such ideas may change the classical views on the molecular mechanism of nutrient uptake and salt and water balance in the body.

Numerous additional papers dealt with modern electrophysiology, cellular biochemistry, endocrinology, and biophysics. The small size of the meeting was conducive to discussion and scientific exchange. (Paula T. Beall, Baylor University)

#### THE XXVIII INTERNATIONAL CONGRESS OF PHYSIOLOGICAL SCIENCES

The XXVIII International Congress of Physiological Sciences was held in Budapest, Hungary, on 13-19 July 1980. The location of the meeting in Budapest allowed for the participation of large numbers of Eastern European and Russian scientists. Attendance was approximately 6,000. The meetings, which lasted 5 days, were pleasantly located in the Budapest Fair Grounds which contained numerous sidewalk cafes and Biergartens for informal discussions.

The opening ceremonies were somewhat politically oriented with addresses by the President and the Minister of Health of the Hungarian People's Republic praising the progress of Hungarian science under the Communist philosophy and Russian patronage. The program of posters and short papers was huge, with over 3,000 presentations in all areas of physiology.

The area of human performance was well covered in the conference. Underwater Physiology, Diving 1 + 2, and Malaysian Nervous System Under Pressure were

of interest to divers. The following sessions dealt with temperature regulation under environmental stress: (1) Adaptation to the Environment, (2) Sports and Work Physiology, (3) Hypo- and Hyperthermia, (4) Effector Mechanisms in Temperature, (5) Central Control of Body Temperature Regulation, (6) Thermoreception, and (7) Hibernation. Seven sessions were related to the performance of aircraft pilots: (1) Effects of Vibration and Noise, (2) Effects of Hypoxia and High Altitude, (3) Performance, (4) Sleep, (5) Limbic System, (6) Behavior CNS, (7) Physiological Bases of Emotion and Motivation.

Six sessions were on gravitational physiology, an area significantly dominated by the USSR and the Eastern European Communist Countries which presented 34 papers out of a total of 57, whereas only 14 came from the US. Since 5 of the US papers described collaborative experiments on the Russian Cosmos 1129 spacecraft, only 9 of 57 papers in this field were solely from US laboratories. Two American scientists did, however, co-chair two sessions: A.H. Smith (Univ. of California, Davis) and N. Pace (Univ. of California, Berkeley). The domination of this area of physiology by Russia was noticed by numerous conference participants and commented upon to American scientists. These international meetings are held only every 3 years, and it appeared from the program of the meeting that the US had not done any research on animals or man in spacecraft or simulated flight for 3 to 5 years. Subsequent discussions with American scientists in this field revealed that since the Biosatellite program lost its funding and the first biological experiments for the space shuttle were not planned until the fourth flight, which could be 6 to 8 years away, American efforts have been limited to collaborative efforts with Russian scientists on the Cosmos series. NASA and NRC managers recognize the slippage of US leadership in this area and are planning a postdoctoral fellowship program for up to 8 young scientists to encourage them to enter this field. However, with restricted funding and small possibility of space experiments, one wonders if the United States can ever recover technological leadership in this area from Russia and Eastern Europe.

The movement of water and salts in the body and its cells was extensively covered in 7 different sessions: (1) Osmoregulation, (2) Epithelial Transport, (3) Trans epithelial Transport, (4) Cell Transport and Metabolism, (5) Electrophysiology and Epithelial Transport, (6) Membrane Transport, and (7) Transport Processes. Some 350 papers, or 10% of the papers in the conference, dealt with aspects of water in biological systems. This is an

area of research that has always had strong support in Russia and Eastern Europe. Prof. J. Tigyi, (Director, Hungarian Inst. of Biophysics) does research in this area and assigns a significant portion of his staff to study these problems. Dr. P.T. Beall (Baylor Univ.), Dr. M.M. Cassidy (George Washington Univ.), and Dr. M. Dinno (Virginia Tech. Univ.) presented papers in this area at the meeting.

Some assorted items of interest were also discussed. For example, Dr. Bertha Knoll (Semelweis Univ. of Medicine, Budapest) has discovered a glycopentide in human serum, called "Satielin," which is capable of inhibiting food intake in starving rats without side effects. This compound may be a natural appetite suppressor which could be used effectively in diet and exercise regimes. Three papers at the meeting dealt with the effects of laser radiation on living systems. Dr. E. Mester (Laser Laboratory, Postgraduate Medical School, Budapest) has shown that cells in the vicinity of laser burns are stimulated to divide and that laser wound closure actually stimulates wound healing over common sutures. Dr. I.V. Bunkin (Academy of Medicine, Moscow) has also demonstrated neurological effects of monochromatic laser light on single neurons at energy levels far below those needed to burn or destroy tissue.

Dr. Julia Timar's paper entitled "Castration-Induced Changes in the Learning Ability of Rats" (Budapest) was the cause of some mirth and concern at the meeting since her experimental results indicated that castration significantly increased the learning abilities of male rats, while not affecting female rats. Other sex-dependent experiments pointed out the importance of the proper experimental and control groups in testing a hypothesis.

Budapest is a modern, bustling metropolis of several million people located on the Danube River. The city is made up of Buda, on a hill on one side of the river and Pest, on the other side. Buda is historic and scenic, with narrow streets, stately old buildings and a castle, while Pest is of post-WW II construction with miles of Russian-style concrete-block apartment houses. Consumer goods were available in stores, and food seemed reasonably priced. Cherries are definitely the national fruit of Hungary: we had cherry jam, cherry brandy, cherry wine, cherry ice cream, cherry pie and fresh sour red cherries all the time. The subway is very modern and fast and most of the conference participants used it to travel to the meetings. The people were polite, but our communication with

them was limited by the language barrier. The most reserved people we met were the border guards on the train. We did not get to visit with Hungarian scientists in their laboratories and socializing seemed to be difficult, possibly because it was too expensive for them to get out for meals or entertainment.

The meeting was most enjoyable and productive. It allowed many of us to meet Russian and Eastern European colleagues with whom we had been corresponding for years, but who do not have international travel funds. Certainly some of the future International Congresses should be held in Eastern Europe for just this reason. (Paula T. Beall, Baylor University)

## OCEAN SCIENCES

### THE MARINE BIOLOGY LABORATORY AT ELAT, ISRAEL

When Dr. J.P. Costlow visited Israel in 1968 (ONR Report 23-68), the only coastal marine laboratory in the country was a small fisheries laboratory in Haifa. However, at that time the H. Steinitz Marine Biology Laboratory of the Hebrew University of Jerusalem was under construction in Elat and plans were well underway to expand the Haifa fisheries laboratory into a major oceanographic and limnology laboratory. This article is concerned with the Elat laboratory; a subsequent article in ESN will tell about the activities of the Haifa laboratory.

The Elat laboratory was officially opened in August 1968 although research work had begun on the site nearly a year earlier. Much of the material presented here comes from a lecture on the development of the laboratory by Prof. E.O. Per of the Zoology Department of the Hebrew University. The lecture was given at the laboratory in March 1977.

Elat, the southernmost city in Israel, is on the northern tip of the Gulf of Elat, a most unusual body of sea water. Until the 1967 war Elat was situated on the narrowest exit to the sea owned by any sovereign state. Suddenly, with the taking of the Sinai Peninsula, 600 km of unexplored coastline were added to the territory controlled by Israel. (To the consternation of some of the people I talked to, the Sinai is now in the process of reverting to Egypt.) In the interim a joint project of the Hebrew University and the Smithsonian Institution resulted in a biological exploration of the whole coastline of the Sinai and the production of over 200 scientific publications on the flora and fauna of

its coastline. Much of this research effort was centered in the new Elat laboratory.

Israeli geologists believe that the Gulf of Elat is geologically the youngest fragment of the oceans. It is the narrowest ocean cleft known with the lowest width to depth ratio, 11:1. Its massive 3.5 to 4.0 m annual surface evaporation places the degree of salinity at its head among the highest in the world (41 o/oo, 4.1%) for a body of water with an unrestricted connection to the world's oceans.

The gulf's vertical and horizontal temperature variations are remarkably slight; the whole gulf from top to bottom has a temperature close to 21°C the year round. From January to March there is complete overturning due to slight winter-time surface cooling that mixes the rather sparse nutrients and oxygen from top to bottom, an unusual happening for a tropical sea.

Although nutrients are scarce, sunlight is abundant and seasonally stable. Many communities of flora and fauna in the gulf are capable of within-community recycling of nutrients. Coral reefs, mangrove swamps, and lagoons are remarkably productive. I viewed dozens of different species of brightly-colored fish from an underwater viewing chamber on a coral reef near the laboratory. When the laboratory was built the gulf was one of the least polluted bodies of water in the world. This is now changing and pollution is an ever-increasing problem. All Israel's oil is shipped into Elat in supertankers and small oil spills are frequent. In addition, Jordan's main seaport, Aqaba, is adjacent to Elat. During my visit about a dozen ships were standing by waiting to unload military supplies destined for Iraq. Over 500 truckloads are said to leave the Jordan port for Iraq each week.

Some interesting symbiotic relationships have developed to support the fauna of the gulf. Microzooplankton are to a large measure dependent on endosymbiotic algal cells. Captive photosynthesis predominates in the plankton and in coral reefs, and even large animals subsist partly on endosymbiotic algae. These include the giant clam *Triton* and the mangrove medusa *Tridacna*. The gulf is rich in the number of species of fish that are present, and this makes it a skin diver's heaven. In addition, several dozen exotic species of flora and fauna have been introduced and are thriving in the gulf.

The above conditions make the Gulf of Elat a very interesting and attractive place to carry out marine biological research. It draws transient research

workers from all of Israel's universities as well as researchers from many other countries in the world. The Elat laboratory operates an 11-m-long Chris-Craft launch outfitted for research.

The bulk of the present resident staff are carrying out mariculture research (see ESN 34-12:560 [1980]) and most of them are employed by the Oceanography and Limnological Research Center in Haifa. However, this group is scheduled to move to larger quarters in the near future, thereby freeing considerable space for other research programs.

The senior permanent staff members employed by the Hebrew University are Dr. Ilan Paperna (marine parasitology), Dr. Yehuda Cohen (marine microbiology), and Jonathan Erez (marine geology). The resident directorship rotates among these three. Major decisions and policies are decided upon by members of an executive committee with members from the laboratory, the Hebrew University, the Universities of Tel Aviv and Bar-Ilan, the Weizman Institute, the Israel Oceanographic and Limnological Research Center, and the National Research and Agriculture Councils.

The geologist, Erez, who was acting director of the Elat Laboratory at the time of my visit, had been called up suddenly for military duty and had not given the correspondence regarding my arrival to anyone. Thus, none of the scientists were present or prepared for me when I arrived. However, they were cordial once they were rounded up and they gave me good and enthusiastic briefings.

I learned that there are plans to start a major project this year with researchers from the Department of Geology at the Hebrew University of Jerusalem and scientists from the University of Lubingen in Germany. The project will be supported by the German Academy of Sciences. The researchers intend to study the paleoclimatology of the Gulf of Elat based on an analysis of bottom cores and radioisotope work. Recent publications indicate that Erez has worked on the stable isotope composition of corals and has used radioactive tracers in the study of symbiotic algae in corals.

Paperna spends most of his time working on diseases and parasites of fish used in the mariculture research program. He found that in the warm water environment at Elat the reproduction level and invasiveness of microbial organisms and parasites is very intense and hyperinfectious readily occurs. The pathological changes in fish which result from injuries, infections, and metabolic disorders develop more rapidly in that milieu than in a cold water environment. One hundred strains of bacteria that attack cultured fish usually through handling injuries.

have been identified along with 14 species of parasites. Cage-reared fish in the natural environment are more likely to suffer parasitic attacks than pond-reared fish. Despite this propensity for illness in cultured warm-water fish, Paperna informed me that most of the problems with infection and attack by parasites had been solved in hatchery-grown and pond-reared fish through research in the mariculture laboratory. Paperna and his associates are now looking into the possibility of diseases and abnormalities induced in fish by marine pollution. The fish disease unit intends to extend its work into diseases of fish in the Mediterranean. They have first-rate facilities for histopathology, bacteriology, and parasitology.

Cohen has been interested primarily in the functioning of solar ponds. His research will be discussed in the February issue of ESN in an article titled "Solar Energy in Israel".

The laboratory's main educational program consists of 15 to 20 short courses. Each course has from 10 to 15 students who attend classes for a week of intensive work. I was told that each course was equivalent to a 40- to 60-hour lecture-and-laboratory trimester course. Instructors come from all three universities in Israel (professors from the Hebrew University teach over half of the classes) and in a typical year several university professors from Europe bring their students to the laboratory and lecture to them there. About a third of the courses are ecologically oriented.

During the past 2 years, 16 students did thesis research at the laboratory or gathered their data for MSc degree theses. Seventeen students worked at the laboratory on PhD thesis research during the same period.

The laboratory's greatest apparent need is for better facilities for teaching and for visiting scientists. Dormitory rooms are very much in demand, as are larger rooms to lecture in and more laboratory spaces for students. The place appeared to be badly crowded. Everywhere I went in Israel I saw individual buildings, each dedicated to a husband and wife (Jewish couples from abroad) indicating generous gifts for construction. The annual reports of the laboratory indicated that some monetary gifts were from wealthy Jews, but apparently these were not substantial enough to aid in the construction of major new buildings. I would certainly recommend the Elat laboratory as an excellent place in which to invest. Its surrounding waters are unique and it is a truly tropical laboratory only a few

hours' flight from all the universities in Europe. Even a modest dormitory and added teaching facilities would be of great help.

People in Jerusalem referred to the Elat area as the Wild West of Israel and the people as being independent pioneer types. It was certainly a rugged enough area to rate these descriptions. (Wayne V. Burt)

#### MARINE ENVIRONMENTAL RESEARCH IN PLYMOUTH

The Institute for Marine Environmental Research (IMER) in Plymouth, England, is a component of the Environmental Research Council (NERC). About 60% of its research programs are funded by NERC (Department of Education and Science); the remainder are funded by the Department of the Environment, the Ministry of Agriculture, Fisheries, and Food, the Environmental Program of the European Economic Community, and the US National Oceanic and Atmospheric Administration (NOAA). With a complement of 114, 82 of whom are research scientists and their assistants, it is, aside from fisheries laboratories, one of the largest marine science complexes in Western Europe.

The institute is housed in a beautiful new (1977) 50,000 ft<sup>2</sup>, 6-story building high on Plymouth Hoe overlooking Plymouth Sound and the Tamar River estuary. The original plan was to build three more similar buildings on the site to provide for expansion of IMER, overflow from the nearby laboratory of the Marine Biological Laboratory of the UK (ENC 28-8:292 [1974]) and some units from the NERC Institute of Oceanographic Sciences at Wormley. Due to the financial crunch in recent years no additional buildings have been constructed, and as a result, the institute enjoys abundant parking space on its campus which is as large as a city block.

The institute grew out of the much smaller Oceanographic Laboratory of the Marine Biological Society in Edinburgh. The director, Mr. R.S. Glover, explained that the establishment of the institute can be traced to a single press conference in the mid-1960s. The SMBA had specialized in plankton sampling in the North Atlantic and North Sea for many years. Data were gathered by towing continuous plankton samplers behind ships of opportunity. They had found (and reported at the press conference) a continuous and dramatic decline in populations of all sorts of species of plankton in both the North Sea and the North East Atlantic.

The decline began in 1948. The abundance of some species dropped to a fifth or less of what it had been previously. The newspapers made a big thing out of the decline and without being told that this was the case, blamed it on increased pollution although data on pollution levels simply were not available to prove or disprove the thesis.

Someone reasoned that if pollution was bad enough to cause a decline in plankton population in the sea it should be much worse and cause more damage in estuaries. Prior to this time the study of estuaries had been the prerogative of universities. Much of the study had been done by PhD candidates. Because of the 3-year PhD cycle, however, estuarine studies lacked continuity. For this reason NERC established IMER with a charter to study estuaries, shelf seas, and the deep ocean. The new institute was established in 1970 when part of the staff in Edinburgh was moved to Plymouth. Later the Edinburgh laboratory was closed and the rest of the staff moved to Plymouth.

IMER's carefully thought out plans and some of their growing pains were well described by Dr. Victor Linnenbaum in 1974 (ESN 28-7:257 [1974]). It is interesting to note that the institute has stuck to its guns and has done a remarkable job of doing exactly what it started out to do, although due to lack of funding its staff is only half as large as was originally planned.

Glover described his goals and methods with messianic ardor. They were exactly as he had presented them to Linnenbaum six years before: "The intention is to achieve a coordinated approach to marine ecology by (1) starting new studies of variability in nearshore waters and estuaries, (2) combining physical and chemical studies with the biological studies of ecosystems, and (3) linking the results of field studies with related experimental investigations in the laboratory." Glover emphasized two aspects of their approach: (1) pollutants will be studied not as separate topics but as parts of the set of environmental variables that affect both plants and animals; (2) an understanding of natural variability is an essential basis for the detection and prediction of any effects that man's activities might have on the marine environment. Overall program planning is directed towards the formulation of models of marine ecosystems.

When Glover was recruiting new staff members in the early 1970s, he took a unique approach for a middle-aged marine biologist. At the time England had a surplus of well-trained young physicists. With some qualms on both sides Glover

recruited a number of physicists and systems analysts for the growing IMER staff. When I interviewed two of them I found one perfectly at home doing the descriptive climatology of the physical oceanography of the North Atlantic and the other appeared to be happy in his research into physical processes in estuaries.

Glover has divided the research personnel of the institute into the following multidisciplinary divisions: Open-Sea Pelagic Systems; Experimental Ecology; Estuarine Systems; Systems Analysis and Statistics; Instruments and Computing; and Analytical Chemistry. When a new subject is taken under study, a task force is set up made up of individuals from several different divisions. As a general rule each individual researcher is not allowed to choose the research subject he will work on but is assigned a job on a team and is told what research he is to do. If he has spare time he can do whatever he chooses. The system seems to work remarkably well.

Most of the efforts of the laboratory are devoted to the following four subjects: the Severn River and Bristol Channel System, all aspects of the Tamar River Estuary that empties into Plymouth Sound, the distribution of plankton in the North Sea and North Atlantic Ocean, and a continuing study of the uptake of pollutants by marine organisms (the common mussel) near the giant oil processing terminal in the Shetland Islands (ESN 34-2:54 [1980]).

Dr. I. Joint discussed Severn River-Bristol Channel mathematical models with me. The first primitive model was made in 1972. This model had been continually improved as more and more data became available until the present model was developed. It is called GEMBASE (General Ecosystem Model of the Bristol Channel And Severn Estuary) and includes the normal array of biological components and processes as well as a hydrodynamic submodel representing transfers of materials between adjacent regions. A submodel for primary production (PRIPRO) is based upon hourly solar radiation data to allow for light-saturation phenomena. GEMBASE does reproduce the large seasonal and regional differences that have been observed within the estuary as well as changes from year to year. Figure 1 shows the interconnecting network representing carbon or energy flow through the system. Solid lines represent flow of carbon. Broken lines indicate flow of nutrients represented as nitrate nitrogen in the current model. The 'ground' or 'earth' symbols indicate losses due to respiration and the double arrow 'interchange' symbol which is similar to the British Rail emblem indicates the transfer of material between adjacent geographical regions within the estuary-channel system.

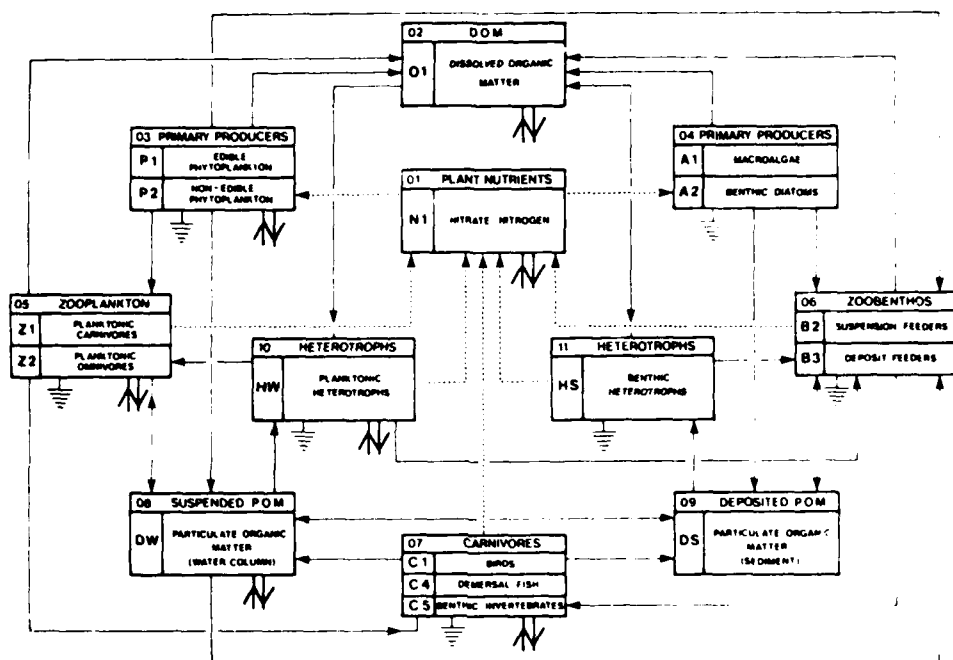


Figure 1. Flow diagram for GEMBASE

An understanding of about 150 processes which transfer energy between about 20 variables is required. Some 200 different equations are used to keep track of the flow of carbon.

Over 25 major surveys have been made of the Bristol Channel and Severn Estuary to improve and test the validity of the model. The model is used to predict and identify problem areas that are then subjected to further research either *in situ* or in the laboratory. The most inaccurate and difficult part of the procedure is estimating benthic production. The model has been used to study the physical and biological effects of placing tidal barrages (for obtaining electrical energy from the tides) at various places in the estuary. It also shows in detail the chain reactions that would follow if any part of the food chain is disturbed.

Dr. J. Widdows explained the laboratory program in which marine organisms, usually the ubiquitous common mussel, *Mytilus edulis*, are subjected to controlled amounts of various stresses and then are examined for physiological (whole animal), cytological (cell) and biochemical responses. The latter two responses are

tested in addition to whole body responses because they are likely to prove more sensitive to environmental changes than some physiological responses and the natural variability is less in the cytology of mussels than it is in their physiology.

The institute has constructed a mobile laboratory in a van which is moved to various sites where mussels can be examined in great detail, fresh out of the water, without subjecting them to the stress of being moved and being kept in a strange environment. Every six months the van is taken to the Shetland Islands to test the mussels around the site of the big oil terminal.

There are physiological differences between strains of mussels in different areas which may cause differences in their response to environmental stresses. For this reason Widdows has selected a clean estuary from which he transplants mussels to various polluted estuaries where he later checks their responses to the pollutants that are present. Thus the animals used are of the same strain.

When I first visited the SMRA laboratory in Edinburgh in 1959, its primary activity was sampling plankton and fish eggs in the North Atlantic and North

Sea from ships of opportunity with continuous plankton samplers developed by Dr. A.C. Hardy and first reported on in the literature in 1936. This research is continuing at IMER. I discussed the program with Mr. A. Taylor. The current sampler, which is called the Undulating Oceanographic Sampler, can be towed at a preselected depth between 15 and 70 m or can be programmed to undulate over any preselected depth interval in the above depth range. It continuously filters plankton and fish eggs on a slowly moving band of silk. It also continuously records temperature, salinity, and depth and has 5 additional channels available for other sensors such as those measuring solar radiation or turbidity.

The recorder is self-contained and generates its own electricity. Thus it can be simply dropped overboard and towed behind any ship of opportunity for up to 1,000 km without attention. In a typical recent year over 200 tows were made in the North Atlantic and North Sea. This work shows, on a month-to-month basis, year after year, how changes in ocean circulation and underwater climate are reflected in the abundance of plankton and fish eggs. These changes have been quite large and are of direct importance to fisheries.

Taylor and his associates have studied ocean temperature data for the past three decades and have been able to ascertain the roles that advection, evaporation, and upwelling play in determining changes in sea surface temperature of the North Atlantic and North Sea. They have found that changes in water temperature and abundances of zooplankton in the North East Atlantic are primarily due to latitudinal displacements in the Gulf Stream.

Dr. C. Tay is in charge of the large computing and instrumentation section. His main job is the management of the computers. In his spare time he is allowed to design and develop instruments. In addition to upgrading the plankton sampler, Tay has recently spent a lot of time creating environments for artificial culture and for experimentation with marine organisms. The idea is to place within an estuary a recording instrument which will record *in situ* diurnal and tidal changes in environmental parameters such as light level, temperature, salinity, and other parameters. These data are stored in a computer and fed to a micro-computer which in turn controls the environmental conditions within an experimental tank. These conditions mimic those which were measured in nature. Experimental plants and animals can then be subjected to nearly natural conditions and their responses can be monitored.

The Tamar Estuary is a typical English riverine estuary that empties into the Plymouth Sound within sight of the laboratory. For this reason it was selected for intensive study. Dr. A. Morris, a chemical oceanographer, discussed the Tamar research with me. The laboratory has a 12-m-long shallow-draft research vessel based in the Tamar Estuary. Its very high speed of 24 knots when loaded allows real-time surveys in the small (12 km long) estuary. The basic parameters, temperature, salinity, oxygen content, and pH are measured routinely and continuously.

Morris and his group are trying to understand and model the chemical processes and rates of processes that take place in estuaries where fresh water mixes with salt water. Very large changes in the concentrations of dissolved organic carbon, oxygen content, pH, temperature, and the concentrations of chlorophyll, nitrate, nitrogen, manganese, zinc, and copper occur at various salinities within the estuary. The fresh water/salt water interface is a chemically and biologically interactive zone and the chemistry group at IMER believes that this zone requires much greater attention and characterization than has been undertaken in previous estuarine investigations. It is now receiving appropriate attention, and the resulting model will be used for control purposes.

One gets the idea that IMER is a very well organized governmental research laboratory and its management system is a model that could be copied with benefit by other governmental laboratories. Goals are rigidly defined and ruthlessly pursued. Glover has developed a finely-tuned system of flexible interdisciplinary attack on environmental research with no prima donnas sitting off by themselves in ivory towers doing their own thing. The remarkable thing was that I heard no complaints and everyone I talked to seemed to be perfectly happy with the system. (Wayne V. Burt)

## OPERATIONS RESEARCH

### OPERATIONS RESEARCH AND RELATED ACTIVITIES IN MOROCCO

I found only one Moroccan who claimed to be devoting most of his efforts to operations research. He was Prof. Abderahman Ali, who took a PhD at the University of California at Berkeley under D. Blackwell, writing a thesis on sequential two-person zero-sum games with perfect information. He spent some years at the University of Paris and at the Sorbonne, and 4 years at INSEA (the National Insti-

tute for Applied Economic Statistics). Two years ago he came to the Mathematics Department at the University of Rabat, more properly known as Mohamed V University. His research activities are in operations research and in stochastic systems. He teaches an undergraduate course in measure theory and probability, and a graduate course in operations research, using Hillier and Lieberman as a text plus some supplementary French material. One other course on operations research is being taught by a visiting professor from France by the name of Faure.

The educational system throughout Morocco is based entirely on the French system. French is the usual language of instruction, although the graduate students are expected to read English text. The undergraduate period is divided into a "first cycle" and a "second cycle," each of 2 years, followed by a "third cycle" involving 1 year of course work and 2 years of research, leading to a degree which is somewhat higher than our MS but well below the PhD level. Many of the instructors in Moroccan universities are French. There seems to be a tendency toward academic conservatism; for example, until Ali arrived in 1978, graduate instruction in the mathematics department consisted typically of courses such as abstract algebra, with very little or nothing in the way of statistics and operations research. However, a number of students are now getting doctorates in various countries outside of Morocco, especially in the US and the USSR, and such modern things as operations research will doubtless be pushed much harder in the near future. The King of Morocco is personally interested in education, and the Moroccan Government (with some aid from foreign countries) is subsidizing the education of these doctoral students.

In spite of the absence of colleagues, Ali appears to be doing good research, under three separate headings. The first involves energy. He is building energy models and doing long-term forecasting of the energy needs of Morocco. This work is just getting underway. He also is building a data bank of energy use in Morocco, and is adapting the MARKAL model (ECN 33-10:411 [1979]), as well as the MEDEE model developed in Grenoble, France, for running on local computers. Finally, he is building a regional model. At present there are political constraints on regional energy considerations (this is a euphemism for the fact that Morocco is essentially at war with its neighbor, Algeria), but in the long run the energy usage of all the countries in the northwest corner of the African continent must be linked. In particular, Ali assured me that the cheapest way of getting

Algerian gas to Europe would be by a pipeline through Morocco rather than by transporting liquefied natural gas, a method which is presently being considered. Morocco does not have any petroleum of its own, but it has large resources of oil shale and is watching with great interest the development elsewhere (especially in the US) of technology for exploiting such shales. There is also a lot of uranium in Morocco, produced as a byproduct of phosphate mining, which leads to a nuclear capability (the first research nuclear reactor has just been completed at the Faculty of Sciences of this university). There is also a great deal of hydroelectric capability because of the high mountain range (the Atlas Mountains) that runs through the middle of the country. Finally, there is a lot of research on solar energy. Since the latitude is favorable (about the same as that of South Carolina and Georgia), the climate generally sunny, and the atmospheric conditions rather clear, solar energy is quite attractive. With all of these resources and very limited capital, decisions must be made now as to where that capital should be invested. It is anticipated that Ali's energy model will be very useful for this purpose.

The second research effort involves a model for education in Morocco. The research to date has not been very sophisticated, but Ali has made some projections to the year 2000; in the absence of anything better, this has been found useful by the government.

Finally, Ali's doctoral students have been working on some aspects of control of the water in reservoirs and dams in Morocco, using both a nonlinear programming approach and a stochastic control approach which has been developed in France. For example, when a dam is first built, there is a question of how to fill it: it is desirable to get it full as rapidly as possible in order to start developing hydroelectric power; on the other hand, the water which could be used to fill the dam is also needed for agriculture, and agriculture is politically important in a country such as Morocco (after phosphate, which constitutes its best known and most important export, Morocco obtains most of its foreign currency by export of agricultural products, such as oranges).

A different set of energy models is being built by Ahmed Abisourour, who considers himself to be working in economics rather than in operations research, although he did take a minor in operations research while working for his doctorate in economics at the University of Connecticut. A very bright and uninhibitedly energetic young man, Abisourour is head of the econometrics division of the Economics Department

of the Bank of Morocco, which is the equivalent of the Federal Reserve in the US, although it does act as an ordinary bank for a few special clients, including the king, his ministers, and employees of the bank.

For his recent doctorate, Abisourour built a computerized econometric model of the Moroccan economy, a massive model requiring 520K of storage. This is far more than is available in the computer at the Bank of Morocco, an IBM 370/115, with 128K of storage; this is by no means small, but Abisourour is optimistic about getting something much more powerful, perhaps a 3300. Meanwhile, he runs his model piecemeal. He is also busy updating the model and constructing a data bank, there being none in Morocco. At the same time, he is attempting to build a staff for his division. Meanwhile he is trying to instruct the rest of the staff of the department in the uses of econometric models. He represents the bank with the IMF and other foreign institutions (he is fluent in English, French, Spanish, and Arabic). He also is beginning to make both short-term and long-term economic forecasts for both the Finance Ministry and the Planning Ministry of the Moroccan government. Abisourour has built a model of money supply as a function of GNP, consumption, borrowing, etc., to control the distribution of money. Moroccan currency, which in the past has been printed in England, is now beginning to be printed in Morocco; this change has called attention to the importance of the following question: after the currency has been printed, how fast should it be distributed? Abisourour's model will be one of the inputs to this decision.

Another "related activity" to operations research is automatic control, in particular as it is devoted to optimizing various processes. This happens to be a very active area at Mohamed V University, where LEESA, the Laboratory for the Study (étude) of Electronics and Automatic Systems, has been set up in the Department of Physics under the leadership of Prof. M. Najim. Najim, who ran the conference "Systems Approach for Development", to be described in a subsequent issue of *ESN*, took his doctorate in signal processing at the University of Toulouse (France). He is a dynamic individual who seems to be more of an administrator these days than a scientist; he also seems to be highly successful as an entrepreneur. LEESA may be the only entrepreneurial research group in Morocco which is successfully operating largely on a self-financed basis. Eighty percent of its funding comes from industrial contracts.

LEESA has a staff of about 20, including faculty and doctoral students. Most of these people are in the Physics Department, but also associated with LEESA are several professors from the Mathematics Department, including Prof. Alj (Operations Research) and Prof. Saad Cherkooui, who took a PhD in pure mathematics at the University of California at Davis; he then switched to applied mathematics and now works in automatic control. Among the leading people on the staff is Najim's brother, Kaddour Najim, who took a doctorate in automatic control, also at Toulouse, and is now interested in process control. Yousri Abdel-Fattah is another prominent member. He took a PhD in aeronautical engineering at the University of Cairo and did postdoctoral work at the University of Grenoble in France and at the University of Trondheim in Norway. He is fluent in English, and wrote a book on the topic of learning systems and adaptive control, published by Springer Verlag in English. His research is primarily in adaptive control for finite state Markov processes, and in stochastic automata games; he has published on these topics in the international literature such as the *Transactions on Systems Man and Cybernetics* of the IEEE. He has also worked with M. Najim and K. Najim on the development of an automatic control system for a phosphate drying furnace, which is important to the Moroccan economy. The objective is to minimize the fuel consumption in the furnace, while bringing the moisture level down from 15% to 1%. In fact, through the development of better instruments to measure the moisture, and sophisticated control devices, the fuel consumption has been reduced by 11%.

Abdel-Fattah also has an interest in the field of resource allocation, which he approaches through a model of stochastic collective behavior which he has developed. Specifically, he is interested in the behavior of a collection of automata, each of which is goal-oriented; that is, each automaton suboptimizes. The problem is to design a set of automata which can approach some overall systems optimum without communicating with one another. The idea is to design automata to solve complex problems by simple rules, each simple rule consisting of the local automaton performing a local optimization.

LEESA also works on some more ambitious projects, such as synthesis and recognition of Arabic speech, but without spectacular results as yet.

Mohamed V University is by far the largest and most prestigious university in Morocco. It has nearly 40,000 students—and it has all the traditional university faculties, whereas each of the other 4

universities in Morocco has only some of them. These other universities are: Casablanca, in the west, with 2 faculties; Fès, in the east, with 3 faculties; Oujda, in the north, just getting started, with 1 faculty; and Marrakech, in the south, with 3 faculties.

I visited the University of Marrakech; it is only 3 years old and is handsomely constructed in concrete with a Moorish flavor. The Faculty of Sciences already has almost 200 faculty and over 2,000 students, all but 6 of whom are undergraduates. It has 5 departments: Mathematics, Physics, Chemistry, Geology, and Biology. The dean, Mohamed Knidiri, has a DSc in physics from the University of Paris. He is a brilliant and dynamic man, but the rest of the faculty seems to be somewhat inexperienced. The man who was reputed to be doing operations research there turned out to be a young man with a master's degree in automatic control who is not doing any research; in fact, very little research is being done at the university as a whole, at this time, although there is considerable hope for the future. I did talk with Mohamed Arsalane, head of the Physics Department, who has a DSc in physics from the University of Rouen in France; he told me of his department's work in solar energy. In particular they are studying photovoltaics. The usual photovoltaic materials, such as Si and GaAs, are too expensive, and they are working instead with CdS, CdTe, and ZnS. The photovoltaic efficiency of such materials is in the range of 1% to 5%, and they are trying to improve these efficiencies. Because they are polycrystalline materials which can be obtained by sputtering or thermal evaporation, they are comparatively easy to prepare. There is considerable hope of electrifying rural villages in Morocco, but they seem to have a long way to go.

Morocco is not ashamed to describe itself as one of the underdeveloped or developing nations, but its people are very ambitious and optimistic. While there is very little of operations research and similar modern approaches to management and control and decision-making in Morocco at this time, I would be very surprised if it were not widespread, active, and efficient by the end of the present decade. (Robert E. Machol)

## PHYSICS

### RESEARCH IN TRANSITION, A VISIT TO DARESBURY LABORATORY

The next-to-last stop on the London-to-Liverpool train run is the town of Runcorn, approximately 20 miles southeast of Liverpool. There I was met one morning by my host, Mr. Mike Poole, who drove me the 6 miles to the Daresbury laboratory, near the town of Daresbury, known as the birthplace of Lewis Carroll. Operated by the Scientific Research Council of the UK for university based users, the laboratory was founded in 1962 as the site for the 5-GeV high-energy machine, NINA (acronym for National Institute Northern Accelerator). Operated successfully for 11 years, the machine was switched off on 1 April 1977 as UK high-energy research was shifted to cooperative endeavors with other European countries. Now the direction of research at Daresbury has changed to include three main projects; computing, nuclear structure studies, and production of synchrotron radiation.

Daresbury is a central computing facility in the UK and is linked to users at universities in Liverpool, Manchester, York, Warwick, and London, and to the Rutherford Laboratory computer center at Chilton. Many of the users have small computers such as PDP-11 for handling small problems, controlling output, and interfacing to the large computer. At Daresbury, access to the main computer is controlled by 3 Interdata 8/16E computers. Main computer services consist of two powerful machines, an IBM 370/16S and CRAY-1.

The IBM machine provides general-purpose batch-processing and time-sharing services to users inside and outside the laboratory. It uses 32 bit words, has 3-Mbyte memory, 8 tape drives and 2700 Mbytes of disc storage. In 1979 the 600 users accounted for a total of over 247,000 jobs.

The CRAY-1, also American made, is a special machine of exceptional power whose use is currently restricted to a selected group of scientists. This computer is physically compact (I mistook it for a small circular lounge), it is designed to handle vectors, and it can perform parallel processing. It has a 4-Mbyte memory, 1200-Mbyte disc storage, and uses 64 bit words in the Cray Operating System (COS) software. Access to the CRAY-1 is achieved only through the IBM 370/16S time-sharing system so that programs can be written in standard Fortran.

Visible for miles and dominating the landscape is the 72-m-(236 ft)-high, 13 m-(42.7 ft)-diameter nuclear-structure facility tower which houses the 30-million-

volt vertical tandem Van de Graff accelerator. In this type of machine the center electrode is positive and both ends are at ground. Negative ions starting at one end are accelerated to the center terminal where they are stripped of some electrons to become positive ions which are then further accelerated to the second grounded terminal. Both heavy ions and protons can be accelerated: for protons the initial acceleration is of  $H^+$  ions (hydrogen atoms with weakly attached extra electrons).

Construction was started in 1974 and is approaching completion. The machine was designed to give a terminal voltage three times higher than was available, at that time, from any other machine—a fact which presented interesting problems. In an ordinary Van de Graff accelerator, charge is transferred via an insulating belt; here, because of the large distances, the charge transfer occurs via an articulated metal ladder whose links are separated by nylon spacers. External insulation against arcing is provided by gaseous Sulfur Hexafluoride ( $SF_6$ ) at a pressure of 8 atmospheres contained in a cylindrical pressure vessel surrounding the accelerator. The immense volume to be filled requires a large amount of gas (120 tons) which presents problems of transport and storage. The gas was shipped from Milan in tank trailers of 3.5-ton capacity (2% of the total) which required many trips and many miles of driving. After operation has commenced, if the accelerator requires maintenance on its interior, the gas will be drained off into a storage vessel. Because  $SF_6$  is denser than air, but not toxic, the hazard it presents to humans is through suffocation. Consequently, an elaborate detector-alarm system is installed to protect the operators and users.

At the top of the tower is the ion-source room which will eventually house several heavy ion sources grouped in a circle centered on the first stage of the accelerator. Changing from one source to another will be done by rotating the bending magnet and connecting tube. At the bottom of the tower powerful bending magnets will bring the heavy ion beams out into several different experimental rooms. At the time of my visit, equipment was being set up in one of them. The accelerator is expected to become operational in 1981 with beam energies of 60 MeV for protons and up to 800 MeV for heavy ions.

A basic principle of electromagnetism is that when a charge experiences forces, and is therefore accelerated, it emits radiation. Synchrotron radiation, long regarded as an essentially wasteful

accompaniment of any curved accelerator, has the important characteristic of high intensity over a broad band from the vacuum UV to the x-ray region. It had been utilized on NINA in parasitic fashion.

During the period between the decision to shut down NINA and the final switchoff, the possibility of utilizing NINA as a dedicated synchrotron radiation source was investigated. This scheme was rejected for reasons both scientific and economic. Instead, it was decided to construct a new Synchrotron Radiation Source (SRS) using the existing buildings and as much of NINA as possible. The project was expected to take 5 years with a target completion date set at 5 Jan 1980 (See ESN 29-8: 367 [1975]). Being much smaller than NINA, the new SRS and its accompanying experimental chambers were designed to fit into the center of the racetrack-shaped NINA. This decision meant that the SRS could not be constructed until NINA was defunct and the central space cleared. Problems with dismantling NINA and clearing out the equipment (one problem was the removal of a 100-ton electrical choke) caused the target date to slip to 30 June 1980 when indeed the SRS began running.

The SRS is designed as a 2-GeV electron storage ring with a maximum current of 1 ampere. It consists of 16 dipole bending magnets of 1.2 T each along with rf cavities and focusing magnets arranged in approximately a 30-m diameter circle. While synchrotron radiation will emanate from each bending magnet, present plans are to provide ports with the possibility of increasing this number to twelve.

Electrons are injected into the storage ring by a 10-m diameter, 500-MeV "booster" synchrotron which is itself fed by a 12-MeV linear accelerator modulated at 500 MHz as a source. Bunches of electrons are extracted from the booster synchrotron and sent into the storage ring where they are further accelerated in 4 copper rf cavity sections of the ring. Supply of the 500-MHz accelerating field to these cavities is in keeping with the general scale at Daresbury—it is conveyed in huge 30-cm  $\times$  60-cm rectangular wave guides rather than in cable.

In the storage ring the electrons circulate in 160 bunches, with a time separation between bunches of 1 period (2.0 ns) of the accelerating field. As the electrons pass through each bending magnet they emit radiation concentrated into a narrow cone centered about the instantaneous electron direction

which sweeps out a fan-shaped region in the orbit plane as the electrons turn. This radiation is a loss of energy which occurs at every bending magnet and must be replaced in the rf cavities. Present plans are for the total power emitted to be up to 100 kW with provisions for increase to 250 kW. Since radiation is emitted in a narrow cone and from a small source (the electron beam) it has small divergence and high brightness. In addition, the radiation has the further experimental advantage of being polarized (parallel to the orbit plane) and emitted in short, well-timed bursts. Each electron is expected to orbit the ring about  $10^{11}$  times before being lost by collision with a gas molecule and therefore the vacuum requirements in the ring are stringent. Each section is pumped to better than  $10^{-9}$  Torr and is bakeable to  $300^{\circ}\text{C}$ . For the initial bakeout of the ring so much heat will be generated that the overhead shielding must be removed so that personnel can work near the equipment.

Operation of the storage ring is expected to be a daily 2-step process. First the ring is charged by operating the Linac, booster synchrotron and rf cavities. When the charging is deemed to be sufficient as indicated by the desired values of the beam current, the booster synchrotron and Linac are switched off and the electrons are allowed to circulate up to, perhaps, 8 hours with the radiation power being replaced by the rf cavities.

The characteristic spectral distribution of synchrotron radiation is a relatively broad peak near the critical wavelength  $\lambda_c$  given by  $\lambda_c = \frac{4\pi R}{3} \gamma^{-3}$  where  $R$  is the radius of curvature and  $\gamma$  is the standard relativistic parameter  $E/E_0$ .

The critical wavelength divides the spectrum equally; half of the total power is radiated at longer wavelengths and half at shorter wavelengths. In practical units  $\lambda_c = 56RE^{-3}$  gives the critical wavelength in angstroms when  $R$  is in meters and  $E$  is in GeV. However, substitution into this formula must be done cautiously for the reason that although the storage ring has a 15-m mean radius, it is not truly circular, but composed of bending magnets and straight sections of focusing magnets and cavities somewhat like a toy train track. Synchrotron radiation occurs in the bending magnets where the radius of curvature of the electron orbit is 5.54 m, giving a critical wavelength of approximately  $3.58 \text{ \AA}$  and a critical energy corresponding to the critical wavelength of approximately 3.2 KeV.

Two beam lines are currently under construction, each leading from a port in the shielding of a bending magnet. One beam line is for vacuum-ultraviolet-radiation (VUV) experiments and has two permanent stations: one, for angle-resolved photoemission studies (metals and alloys) in the 50-400  $\text{\AA}$  region (0.250-3.00 KeV), is being equipped with a monochromator and large precision spectrometer, the other is being readied for Surface Extended X-ray Absorption Fine Structure (SEXAFS) studies.

Some years ago it was shown that the radial distribution function for the short-range order near an absorbing atom can be determined from measurements of the fine structure of the x-ray absorption in the neighborhood of an absorption edge. The method has become known as EXFAS; the station being instrumented will apply this method to the study of surfaces (SEXAFS) in the 0.250 to 10 KeV region (50 $\text{\AA}$ -1.2 $\text{\AA}$ ).

The other permanent beam line is devoted to x-rays and is split into 3 stations: (1) EXFAS measurements, principally in transmission; (2) protein crystallography and fiber diffraction in the 1-4  $\text{\AA}$  range; and (3) a very long line, which goes to the limit of the building, about 80 m from the source. This line is to be used for topography studies of crystals where a very good approximation to a point source is desired.

The two beam lines are expected to be partially ready for use by mid-February 1981 and to be fully in use by summer. Other beam lines are scheduled to become operational in late 1981: (1) a far infrared line ( $\sim 100 \mu\text{m}$ ) to be used mainly for studying the chemistry of molecules, (2) a line with a large-aperture port to be used for time resolved spectroscopy. These, as well as two other lines whose construction will depend on finances, can become operational without shutdown of the storage ring. A wiggler beam line for use in the 0.1  $\text{\AA}$  region will be ready for installation by the end of 1981. This modification, which will include the introduction of a 5-T superconducting magnet into the storage ring will necessitate a shutdown of approximately 1 month and will be scheduled so as to have minimum interference with other experiments.

Physics at Daresbury has changed direction since the original construction of NINA in 1962. The conversion period has been somewhat lengthy as is natural for such a large project, but by the end of 1981 research will be underway in many new and exciting directions. (John R. Neighbours)

SOME SOLID STATE PHYSICS IN THE  
NETHERLANDS II—NIJMEGEN

NIJMEGEN

Famous at least from the film "A Bridge Too Far", about the closing phases of WWII, the city of Nijmegen is located by the side of the busy Waal River in the province of Gelderland. Said to be the favorite residence of Charlemagne in the 8th century, the city was chartered in 1184. The Catholic University (See also ESN 30-9:428 [1976]) which I visited is located a short distance from the center of the old town. It was founded in 1923 by the Sacred Congregation of Studies and by Royal Decree, and follows the doctrine of the Roman Catholic Church. Although it is a private institution the university does receive financial support from the state and the university degrees are equivalent to those of the Netherlands state universities.

My host, Prof. P. Wyder, who is chairman of the Solid State Physics Group and president of the Dutch Physical Society told me that the Faculty of Science which includes Biology, Mathematics, Chemistry and Physics had a total complement of approximately 600 including technicians. Of these, 200 are in the Physics Department with about equal division between academics and technical staff. Only 12 in the Department of Physics are professors; two of them in solids, Wyder and Prof. A.R. de Vroomen, who is interested in deHaas-van Alphen measurements and band structure calculations.

Wyder's group consists of 2 PhDs, 6 graduate students and approximately 15 undergraduates who spend 1½ years in laboratory work. During his many years at Nijmegen, Wyder's research has been quite catholic with recent work centered on transport properties and the interaction of matter with radiation. In a 1977 PhD dissertation sponsored by Wyder, H.N. de Lang presented measurements of low-temperature thermal conductivity in magnetic insulators and the pure metals aluminum and indium, and supercooling-superheating effects in indium at temperatures near the superconducting transition ( $T_c \sim 3.40$  K). The compounds  $[\text{CuH}_{n+1}\text{NH}_2]_2\text{CuCl}_2$  are 2 D Heisenberg ferromagnets in which the magnetic ions are arranged in layers. de Lang measured the thermal conductivity of the orthorhombic  $n = 1$  ( $T_c = 8.895$  K) and  $n = 2$  ( $T_c = 10.20$  K) compounds in the temperature range of 1 to 25 K and as a function of magnetic field. Below  $T_c$  de Lang found the conductivity to be mainly ( $\sim 90\%$ ) by magnons (quantized spinwave). Above  $T_c$  he found a magnetic contribution of up to 95% which he attributed to paramagnons (paramagnetic short-range order magnons).

These results are claimed to be the first experimental verifications of the paramagnon contribution to thermal energy transport. In his measurements of the low-temperature thermal conductivity of Al and In, de Lang reduced the electronic contribution by application of a magnetic field and was therefore able to measure only the lattice thermal conductivity, the results showing the expected  $T^2$  dependence and being in agreement with measurements made by the alloying technique.

Measurements of the electrical resistivity of K and Al in the temperature range from 1 to 4 K were recently completed by another PhD candidate, Mr. J.H.J.M. Ribot, who used a self-balancing bridge capable of measuring small resistances (down to  $5 \times 10^{-7} \Omega$ ) to a precision of 1 ppm (*Rev. Sci. Instr.* **50**(2) 161 [1979]). Both sets of measurements show a  $T^2$  term ascribed to electron-electron scattering. The Al results show an additional  $T^5$  term which is expected to result from electron-phonon (e-ph) scattering in the "dirty" regime where the part of the resistivity resulting from e-ph scattering is much less than the residual resistivity. Plotting the data as  $T^{-1} d\rho/dT$  vs  $T^3$  separates the two terms, the slope giving the coefficient of the  $T^2$  term.

This analysis holds for data taken below  $T = 2$  K (and above the superconducting transition  $T_c = 1.18$  K), but for higher temperatures up to 4 K the variation of the e-ph scattering term is slower than the expected  $T^5$  and depends on the purity of the sample.

A different type of experiment, the interaction of far infrared (FIR) radiation with solids has been performed by two other recent PhD recipients. Dr. C.G.C.M. de Kort generated radiation in  $2\text{cm}^{-1}$  to  $25\text{cm}^{-1}$  band ( $\sim 50$ -60 GHz) using a millimeter wave klystron connected in series to a harmonic generator and a grating monochromator which selects the desired frequency from the generator output. The nonlinear diode element in the harmonic generator is a boron-doped silicon crystal with an electrolytically pointed ( $\sim 1\mu\text{m}$ ) tungsten whisker electrode. Using several different klystrons, the system can be tuned continuously over the entire frequency range.

Using this apparatus, de Kort has performed high-resolution infrared spectroscopy on the lower energy levels of  $\text{Cr}^{3+}$  in a MgO host crystal in magnetic fields up to 2.5 T at temperatures between 1.2 and 4.2 K. Extrapolation of the electron paramagnetic resonance (EPR) frequencies to zero frequency gives an energy-level scheme in close agreement with theory. However, for some inexplicable reason, the g factor is quite different

from the theoretical prediction. In contrast, EPR experiments on  $\text{Cr}^{+3}$  and  $\text{Fe}^{+2}$  in the same samples gave g factors in agreement with theory and with other experiments.

Far infrared cyclotron resonance was performed by J.C. Maan who used a laser source. A CW operating  $\text{CO}_2$  laser mechanically chopped at 23 Hz was used as the pump for a FIR laser using the permanent electrical dipole moment materials  $\text{CH}_3\text{OH}$  and  $\text{CH}_3\text{OD}$  as media. Maan observed cyclotron resonance induced conductivity (CRIC) in n-GaAs at wavelengths of 119, 70.6 and 57  $\mu\text{m}$  at temperatures between 4 and 40 K. The increase in conductivity which has a peak in the vicinity of 15 K is ascribed to two effects: above 15 K the CRIC is due to changes in the free carrier density only, while below 15 K the mobility also changes.

Maan also measured cyclotron resonance in the superlattice formed by deposition of alternate layers of InAs and GaSb which have an almost perfect lattice match (6.058 Å and 6.095 Å respectively). The extra periodicity introduces extra divisions of the Brillouin Zone into subzones and extra divisions of the energy bands into subbands separated by small gaps. Perpendicular to the superlattice layers the effective mass depends on the curvature of the subband; in the plane of the layers it depends on the effective mass in the materials of the layers and is therefore highly anisotropic and easily investigated using cyclotron resonance. The results using the same FIR wavelengths show the anisotropy through a marked angular dependence and demonstrate the 2-dimensional character of the superlattice.

Some of the above experiments required high magnetic fields. Dr. Harold Myron, scientific coordinator of the High Magnetic Field Laboratory (HMFL), showed me the hybrid magnet which was developed in a joint venture between Nijmegen and MIT. This system, capable of producing the highest dc magnetic field outside the US, consists of a concentric pair of water-cooled coils surrounded by a superconducting magnet, and is capable of producing a 26 T field in a bore of 32mm. To produce this field requires a power of 6 MW provided by two 3 MW power supplies which produce a 10,000 A current at 300 V. The cooling facilities consist of a 150-ton ice bunker and two 1000-gpm water pumps. In addition to providing support for experimenters at Nijmegen, the HMFL is open to all physicists of the world.

Even higher magnetic fields are being utilized by Prof. A.R. de Vroomen and Dr. A. van Devrsen who have been conducting pulsed field deHaas-van Alphen effect measurements. They discharge a large

capacitor charged to 5 Kv through a 1 mH coil of approximately 2.5 cm bore to obtain the needed 41 T field. The coil is cooled in a liquid nitrogen bath which is removed immediately before pulsing in order to reduce noise. de Vroomen and van Devrsen have completed measurements on AgAu alloys which are to be published soon and plan to continue work on PtBi.

Relativistic augmented plane wave (APW) band structure calculations are being carried out by a group headed by Prof. F. Mueller. They have made calculations on the B-15 material PdSb, and on the C-15 materials  $\text{TiBe}_2$ ,  $\text{ErZn}_2$ ,  $\text{YAl}_2$ ,  $\text{LaAl}_2$  and  $\text{UAl}_2$ . A.T. Von Kessel, along with Myron and Mueller presented an invited paper on the fermi surface of Nb, Sb at the Physics of Transition Metals Conference at Leeds in August (see forthcoming ONR Conference Report) in which they claimed this calculation to give the highest precision fermi surface now known for any A-15 material. Myron and Mueller in collaboration with C.B. Summers (Univ. Paris, Sud) have recently finished a calculation of the density of states of the entire NiCu system. This result, claimed to be the first application of the supercell method invented by W. Kohn to a real system, has been submitted for publication. GRONINGEN

The most northerly province of the Netherlands is Groningen, which derives its name from the "Villa Groninga" given to the bishop of Utrecht in 1040 by Emperor Henry III. The city was walled in 1255, taken by the Spanish in 1580, and recaptured in 1594. Shortly after, in 1614, the University of Groningen was founded and quickly became one of the greatest in Europe, famous for its outstanding library.

On a rain-free morning (which soon changed) I met an old acquaintance, Prof. A.J. Dekker, who conducted me down old narrow streets to the Solid State Physics Laboratory, a division of the Materials Science Center of the university. Dekker returned to Groningen from the US in 1960 and shortly after began the formation of the center which was officially constituted in 1970.

During the past several years, Dekker, in conjunction with Dr. W.H. deJeu and Dr. F. Leenhouts, has studied the physical properties of nematic liquid crystals. As is well known, these materials have a nematic phase between the melting of the crystalline solid at  $T_m$  and the onset of the isotropic liquid phase at the transition temperature  $T_c$ . They have measured the magnetic susceptibility, density and entropy of 11 structurally related Schiff's bases (chainlike organic compounds with  $18^\circ\text{C} < T_m < 106^\circ\text{C}$  and

46°C <  $T_c$  < 118°C) in the neighborhood of the transition temperature. The results for these compounds are interpreted as follows: (1) there appears to be a relation between the value of the order parameter evaluated at  $T_c$  and the relative volume change at  $T_c$ ; (2) the trends observed can only be accounted for by a theory which includes flexibility of the molecules; (3) the entropy change at  $T_c$  increases with chain length, a fact which is not explained by a simple Landau expansion of the free energy in terms of the order parameter.

The elastic properties of these liquid crystals are described by 3 constants (not cubic symmetry) which relate to the basic distortions of splaying, twisting and bending. Using optical-magnetic methods these constants, which are strongly dependent on the temperature near  $T_c$ , have been measured for many of the same compounds. The results show that near  $T_c$  the ratio of twist to splay elastic constants increases almost linearly with the length-to-width ratio of the molecules. Further details on all measurements are to be found in two recent publications. (*J. Phys.* [Paris] 40 C3-291 [1979] and *J. Phys.* [Paris] 40 989 [1979]). More details on the elastic constants in particular are to be found in Leenhouts' PhD thesis (F. Leenhouts, Dec. 14, 1979 Univ. of Groningen).

On the day of my visit, the department head, Prof. W. van der Lugt, was ill. His colleague, Dr. B.P. Ablas, told me about the work on liquid metals and alloys. X-ray diffraction has been used to determine the structure factors of liquid Na, K and Cs at temperatures up to 423 K. With rising temperature, the height of the first peak gradually decreases and the following oscillations become more damped. A neutron diffraction determination of the structure factor of Na was in agreement with the x-ray results; that for Cs was in agreement only if the neutron cross section was substantially modified. In further work, both x-ray and neutron determinations of the structure factor were carried out over the entire range of composition of NaCs alloys with the results expressed as a set of 14 diagrams. A liquid binary alloy is described by three partial structure factors which consequently require three independent measurements for a complete determination. The x-ray data and neutron data are considered to be two of these; the third is a computer simulation according to some model. Unfortunately, since the definition of the partial structure factors is not unique, this leads to some ambiguity, and results in large uncertainties in these derived quantities. (Further details can be found in *Physica* 97B 338 [1979]).

Alloys of Li are also of interest to this group as shown by a recent publication (*J. Phys.* F 10 1177 [1980]) in which measurements of electrical resistivity and the Knight shift (change of the required magnetic field for NMR in a metal) in liquid LiCd alloys are reported. The resistivity has a peak near 40 atomic percent Cd at which composition the temperature derivative of the resistivity becomes negative as is to be expected in an alloy where the average valence is increasing from one to two. The Knight shift of  $^7\text{Li}$  varies linearly with Cd content, but has a discontinuity in slope at approximately 50 atomic percent.

At temperatures close to the liquidus, two different  $^7\text{Li}$  resonances are sometimes observed; this is attributed to the presence of both liquid and solid particles. Similar measurements on LiMg alloys are being prepared for publication and an apparatus for measurements on LiSn alloys is under construction.

Insulating crystals have been extensively investigated by Dr. H.W. den Hartog who has published many papers on dipole interactions in rare earth doped materials. A recent PhD thesis written by E.J. Bijvank under the direction of Dekker and den Hartog looked at the crystal field splitting in fluorite type crystals. These materials have a structure in which the sub-lattice of negative ions has a simple cubic structure and alternate cubes are filled with a centrally located divalent cation. Introduction of a substitutional trivalent rare earth ion into a divalent cation site gives an excess positive charge which may be compensated by an extra  $\text{F}^-$  anion located at the adjacent normally empty site in the center of 8  $\text{F}^-$  ions. The excess charges attract each other forming a local charge compensation center; other charge compensation centers can occur at larger distances.

Simultaneous doping with a trivalent rare earth ion and a monovalent alkali ion can result in both dopants occupying nearby substitutional sites and formation of a more complicated  $\text{R}^{3+}\text{-M}^+$  charge compensation center. Bijvank doped  $\text{CaF}_2$ ,  $\text{SrF}_2$ ,  $\text{BaF}_2$  and  $\text{SrCl}_2$  with  $\text{Gd}^{3+}$  and the alkali metal ions and subsequently published his findings in several research papers of which the latest is *Phys. Rev. B* 17 37 (1978). Further work is reported in his thesis where the relaxations of 44 of the ions in the vicinity of a charge compensation center are calculated. (Measurement by x-rays is not possible because of the low concentration of centers.) Using these results with no adjustable constants, Bijvank has calculated the first two magnetic crystal field parameters as a function of the ionic radius of the alkali metal ion.

Agreement with experiment is reasonable for the first parameter  $B_2^0$  but poor for the next higher parameter  $B_4^0$ . den Hartog believes that the agreement can be improved by including relaxations of more ions in the vicinity of a charge compensation center. Currently he is working at improving the program since each point requires several hours of machine time. He also plans to perform ENDOR measurements on the monovalent ions using a special low-frequency setup at the University of Delft in order to obtain an independent check of the  $Gd^{+3}$  and  $Li^+$  displacements.

Groningen was my last stop in a tour through the Netherlands. Judging by the variety and intensity of the research I saw, physics is very big in this relatively small country. (John R. Neighbours)

## NEWS and NOTES

### FRENCH TAKE MANHATTAN

A French firm has invaded the US optical communications market to install a 6.5-km fiber system in Manhattan. CIT-Alcatel, the leading French telecommunications company, announced recently that it had beaten off competition—including the giant ITT—to supply the link to Western Union Cable and Telegraph Company. CIT officials believed that the system, scheduled to begin operating in January, 1981 would be the first fully operational optical fiber link in the US.

CIT is also supplying the second such link, an experimental one which the company sold to Western Union just over a year ago. Together with the new link, which uses light-emitting diodes to convert electrical signals into light, the experimental link, which uses laser diodes, was also to be put into regular use.

The great advantage of optical fiber systems for Manhattan derives from the fact that available cable ducts under the city are physically crammed to capacity, so that it is now almost impossible to feed through standard electrical links. Optical fiber links, however, can be made on cables 10 times smaller in outer diameter—allowing a hundredfold increase in channel capacity for the same duct cross-section.

The CIT system uses cables of 1 cm outer diameter to carry 44 megabits per second (672 telex channels). CIT supplied the input-output devices and the data management system for the link. The company considers this first step in the US market to be only a fundamental one and believes that the potential scale of the market is huge.

### LONDON ATTRACTS "ION MAN"

A leading world expert in the micro-analysis of semiconductors has been appointed Sir John Cass senior visiting fellow at the City of London Polytechnic.

Dr. Klaus Wittmaack, of Munich, is to spend the next year advancing the secondary ion mass spectrometry (SIMS) technique which is considered crucial to the development of future generations of silicon chip technology.

The key to the initiative demonstrated by Wittmaack is the ability to detect the minute concentrations of impurities which determine the properties of silicon chips—down to one part in a thousand million.

Wittmaack will work on a department of physics extension of the SIMS program, embarking on a combination of SIMS with the molecular beam epitaxy process which will enhance the ability to examine semiconductor samples at various stages of preparation.

While Dr. Wittmaack has spent some time in the United States he has decided against Silicon Valley in favor of Europe to pursue his studies.

### POLYMER LIBRARY ESTABLISHED

A \$100,000 library of documents and pictures which will help scientists to develop polymer products is to be set up at Lancaster University. The library of Polymer Applications, which is being assembled by the chemistry and engineering departments, is supported by the Science Research Council and will include accounts of recent work in processes, materials, and products involving plastics.

The director of studies in polymer science and technology, Dr. Roy Smith, said that because polymer science was such a new and complex field, understanding of its different processes and applications was still fragmented. "Scientists and engineers in industry and higher education institutions are often involved in analyzing and developing separate parts of the overall problem without being able to judge how developments in their particular field relate to work elsewhere."

The library will consist of a series of case studies based on industrial products and will cover the selection and development of polymer materials explaining the details of fabrication such as injection molding, extrusion, casting, and compression molding.

Actual examples will include train and truck cabs made from plastics, bulkheads and aircraft floors, washing-machine tanks and containers to store acids. In all cases the plastic products have been found to have a better performance than those made from traditional materials.

The idea to set up the library follows a recent visit by the Science Research Council's polymer engineering directorate to Lancaster's polymer museum, a collection assembled by Dr. Smith over the past 15 years.

# OPERATIONS RESEARCH SOCIETY AWARDS, 1980

A special meeting of the Operational Research Society (ORS) of the United Kingdom was held at the London School of Economics on 20 November 1980 for the presentation of awards by the society's president, George H. Mitchell.

The Goodeve Medal was named for Sir Charles Goodeve, a founder of the ORS who died in 1980. It is awarded in recognition of an outstanding contribution to the philosophy, theory, or practice of OR in the form of an article published in the society's journal. This year's award was to Adrian J. Williams of PA International Management Consultants Ltd., for his paper, "From Planning Board to Welding Hall: A Case-Study in OR/Client Involvement," published in November 1979 (Vol. 30, pp. 941-952). The citation mentioned the "clear and at times vivid exposition" which complemented a remarkable piece of work.

The Prospect Award is the only one of the three presented by the ORS which carries a cash emolument. This award is for a piece of work rather than for a publication. The most likely candidates for the Prospect Award have two distinctive features. One is the team nature of much of this work—and here is meant not just an OR team, but an OR input to a more widely based team. The second is that such work is often the consequence of a long-standing program and not just a single project aimed at a single decision. It was awarded this year to D.W. Sutton of the Corporate OR Department of the British Steel Corporation for his work on raw materials input in the making of stainless steel.

The President's medal is also awarded for a contribution published in the society's journal; in a year when the Goodeve Medal has been awarded, the President's Medal is awarded for the contribution judged second best. It was awarded this year to Peter Doyle and Ian Fenwick (Univ. of Bradford Management Centre) and G.P. Savage (Yorkshire Bank) for their paper, "Management Planning and Control in Multi-Branch Banking," published in February 1979 (Vol. 30, pp. 105-111). The paper describes a regression model, and the citation noted the care with which the variables had been chosen and the thoughtful consideration of causality—aspects that are often missing in such models—as well as the conciseness and clarity of the writing.

Each of the winners gave a 30-minute presentation of his work at the meeting. (Robert E. Machol)

# SPENDING RESTRICTIONS THREATEN QUALITY OF UK UNIVERSITY EDUCATION

The UK University Grants Committee (UGC) has told the Government that lack of funds means that it will probably have to abandon its traditional policy of maintaining excellence in all disciplines. Dr. Edward Parkes, chairman of the UGC, has warned that there may be less than level funding for well-founded laboratories for research. Parkes said that the resources are no longer likely to be available to maintain fully the traditional policy of working towards attainment of excellence in as many disciplines as universities might wish. He added that in the long run, smaller institutions might have to concentrate their particular strengths in a limited number of fields, and that there would have to be more collaboration among institutions.

According to the UGC chairman, this situation is without precedent in the recent history of UK universities, because heretofore change has been possible in a system of increasing student numbers. In the future, however, resources for new developments and activities will only be found at the expense of others.

# THE CRISIS OF STAFF STAGNATION

University staffing levels are a perennial problem in European higher education, and a major headache among them is the crisis over staff stagnation. A recent report by the European Science Foundation warned there was a danger of "irreparable" loss of research talent in Europe because too many academics were in the younger age groups and new recruitment was often far below the 3 percent per annum required to put this right.

One of the countries highlighted was West Germany, which is likely to provide only about half of the rate of replacements demanded. To counter this, the Heisenberg scheme, named after the noted German physicist, was introduced to provide new research posts and increase the academic pool by 1 percent a year.

Sadly it has proved to be anything but a success. This can be judged from the scheme's figures. A total of 150 posts were to be offered each year from 1978. Last year only 57 applicants were considered well enough qualified to fill these posts. Indeed, a maximum of 750 posts were to be introduced over a five-year period, but by last year only 117 had been filled.

The reasons for the poor response are not hard to understand. Unlike Britain's special release fellowships, which allow

older academics to leave posts to conduct research, thus providing tenured jobs for young workers, the German scheme directly provides places for young researchers under the age of 35. Considering that the average age for finishing a PhD is 27 in Germany, this gives promising young scientists little time to gain a high reputation and research output sufficient to satisfy the Deutsche Forschungsgemeinschaft (the DFG—a close equivalent to the United Kingdom's Science Research Council) that they are worthy of a post.

Worse than that, the posts are limited to only a five-year tenure; this provides little security for a researcher who will understandably prefer more secure offers from industry.

#### ONRL STAFF CHANGES

We recently welcomed Commander Richard E. Ashford, Surface Weapon Systems Officer, who came to ONR London from the US Navy Engineering Duty Officer, Mare Island, Vallejo, California, where he had served as the assistant for combat systems and the director of the basic course. In the past month, we said farewell to two of our liaison scientists. Dr. Wayne V. Burt, who had been at ONR London since January 1979, returned to his post as associate dean of the School of Oceanography at Oregon State University. Dr. Moses A. Greenfield, who had spent a sabbatical year with us, returned to the University of California, Los Angeles, where he is professor of radiological sciences.

#### THE QUEEN'S NEW YEAR HONOURS LIST

The following persons in UK universities, science, and technology have been included in the 1981 New Year Honours List:

Knights Bachelor (KB): John Bertram Adams, director general, European Organization for Nuclear Research; Prof. Desmond A. Pond, president, Royal College of Psychiatrists. Order of the British Empire (OBE): Prof. G.S. Dawes, director, Nuffield Institute for Medical Research, Oxford; H. Kay, vice chancellor, Exeter University. Order of the British Empire (OBE): A.M. Currie, secretary, Edinburgh University; M.R. Horne, Bever Professor of Civil Engineering, Manchester University.

#### ONR COSPONSORED CONFERENCES

OHOL Conference on "Biomimetic Chemistry and Transition-State Analogs: Approaches to Understanding Enzyme Catalysis," Zichron Yaakov, Israel, 2-25 March 1981.

International Conference on Creep Fracture of Engineering Materials and Structures, Swansea, UK, 24-27 March 1981.

Conference on Interfaces in Composite Materials, Liverpool, UK, 1-2 April 1981.

2nd International Low Temperature Biological Microscopy and Microanalysis Conference, Cambridge, UK 6-9 April 1981.

8th International Gas Bearing Symposium, Leicester, UK 8-10 April 1981.

International Seminar on the Role of Finite Element Methods in Radiation Physics, London, UK 23-24 April 1981.

Symposium on "Polymer Liquid Crystals—Science and Technology," Portofino, Italy, 18-22 May 1981.

International Symposium on Osteoporosis, Jerusalem, Israel, 31 May-4 June 1981.

International Symposium on Locational Decisions (ISOLDE II), Skodsborg, Denmark, 15-18 June 1981.

Conference on "Modification of the Surface Properties of Metals by Ion Implantation," Manchester, UK, 24-26 June 1981.

9th International Conference on Operational Research, Hamburg, Germany, 20-24 July 1981.

International Symposium on Hydrodynamics in Ocean Engineering, Trondheim, Norway, 24-28 August 1981.

NATO Advanced Study Institute on "Static and Dynamic Properties of the Polymeric Solid State," Glasgow, UK 6-18 September 1981.

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European Visitors to the US Supported by ONR London

<u>Visitor</u>	<u>Affiliation</u>	<u>Navy Lab./Org. to be Visited</u>
	<u>MAY</u>	
Dr. D.E. Packham	Univ. of Bath, School of Materials Science, Bath, UK	NSWC, White Oak

## ONAL REPORTS

C-5-80

Simulation '80 Symposium by Richard L. Nance

This report of the Simulation '80 Conference held in Interlaken, Switzerland on 25-27 June 1980, focuses on the methodological and technological sessions. The report is divided into four topical areas: (1) methodological issues, (2) computing hardware, (3) computing software, and (4) simulation applications. A concluding summary draws a brief comparison between the current research interests in Europe and the US.

C-7-80

International Union of Theoretical and Applied Mechanics: 3rd Symposium on Creep in Structure by Terry R. McNelley

The 3rd Symposium on Creep in Structures was held September 8-12, 1980, at the University of Leicester, UK. The Symposia in this series occur once every ten years with the aim to review developments in the area of creep and creep mechanics. As such, this Symposium, with a total attendance of about 70, attracted many prominent workers in this field. Over the years, emphasis in this field has shifted from analysis of creep mechanics toward the problems of cavitation, void formation, creep cracking and rupture. This change is in part a result of metallurgical developments leading to stronger, more creep resistant materials but also less ductile materials. This was reflected in this Symposium as half the papers dealt with the various problems in the areas of cavitation, creep crack propagation and rupture. Furthermore, there was a significant input from Metallurgy and Materials Science and the promotion of interaction between the Mechanics and Materials Science approaches to the subject of creep was an important secondary aim of this Symposium.

C-9-80

Second International Conference on Superconducting Interference Devices and Third Workshop on Biomagnetism by John R. Neighbours

This report covers the conferences on superconducting quantum interference devices and biomagnetism held in West Berlin on 6-9 May 1980. Subjects discussed were junction physics, junction and circuit noise, fabrication of junctions and circuits, high and low frequency applications, and applications. Ten invited and 62 contributed papers were presented at the SQUID conference.

C-10-80

Meeting on the Physics of Transition Metals Leeds, UK, 18-22 August 1980  
John R. Neighbours for Dimitris Papaconstantopoulos and Barry Klein

This report covers the conference on transition metals held in Leeds on 18-22 August 1980. Subjects covered were band theory, ferromagnetism, ultrasonic attenuation, neutron scattering, magnetism, Fermi surfaces, positron annihilation, lattice dynamics and heats of formation. The meeting included 25 papers, 4 poster sessions and a panel discussion on magnetism in metals.

R-2-80

Energy from the Bowels of the Earth—Vulcanism and its Uses in Iceland by Robert J. Machol

Iceland is far ahead of the rest of the world in the use of geothermal energy for hot water and space heating, but they have run into severe difficulties in generating electricity from this source. The present report describes these difficulties and some of the people involved.

R-3-80

Key Organizational and Management Research Thrusts in Europe by J.G. Hunt

A sabbatical at the University of Aston Management Centre, Birmingham, UK and visits to other similar UK and Dutch centers revealed major thrusts in the nature of organizational and management research in Europe.

In general, there is considerable research of this kind being conducted in Europe. Its flavor is summarized in this report.

The work differs from that being done in the United States in a number of ways. One is the emphasis on cross-national studies. There are a number of such European projects involving centralized research designs but decentralized funding and implementation modes across institutions in different countries. While such research is done in the US, it does not play the dominant role demonstrated here. Neither is the centralized design, decentralized implementation mode common.

A second difference is the emphasis on research concerning work place participation. Though rare in the US, such schemes are commonplace in Europe. A third difference is in the way leadership research is treated in Europe and the US. Such work is more heterogeneous in Europe and is frequently treated as part of another project, not as a research area in its own right as in the US.

R-4-80

Marine Science in Southern Wales by Wayne A. Burt

Marine science programs are concentrated in the cities of Swansea and Cardiff. Marine research is being carried out in the departments of oceanography, chemistry, chemical engineering, economics, geography, metallurgy and materials science, mechanical engineering, civil engineering, geology, and zoology at the University College of Swansea. The Department of Maritime Studies at the University College of Wales in Cardiff has research and instructional programs in maritime technology, maritime geography, maritime commerce, sea law and policy, shipping economics, marine geology, and marine meteorology. Some deep sea and Bristol Channel seismic research is also underway in the Geology Department of the University College of Wales in Cardiff.

C-8-80

5th International Conference on Marine Corrosion  
and Fouling by E.C. Haderlie and R.C. Tipper

This is a brief account of the Fifth International Congress on Marine Corrosion and Fouling held in Barcelona in May 1980. A list of the papers presented is included, however, no abstracts are given for the preprints of all papers have been published and distributed.

C-12-80

European Workshop in Leadership and Managerial Behavior—  
University of Aston Management Centre by J.G. Hunt

A sabbatical at the University of Aston Management Centre, Birmingham, UK, and visits to other similar UK and Dutch centers revealed major thrusts in the nature of organizational and management research in Europe.

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R-5-80

A Partial Review of Marine Science in Western Europe by  
Wayne V. Burt

This review contains short summaries of marine research and comments on these activities. Each country summary is followed by a series of discussions of individual centers of marine research. The discussions include the research programs, sources of funding, key personnel, trends and comments. The review is essentially complete for Spain, Portugal, and The Netherlands, and partially complete for the UK and France.

R-7-80

Research Policy in the Federal Republic of Germany by  
W.J. Conde'll, Jr.

The research policy of the Federal Republic of Germany as described in Bundesbericht Forschung VI, 1979 is abstracted and compared with trends in the OECD nations as described by the OECD Committee for Scientific and Technological Policy, 1978. Funding estimates for R&D sectors are given. Lists are given of the Big Science establishments, the Max-Planck institutes, and Franhofer institutes.

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